Upper Hangman Creek Assessment and Total Maximum Daily Load

Draft

Department of Environmental Quality

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Acknowledgments

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Abbreviations, Acronyms, and Symbols

§303(d)	Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section
µ	micro, one-one thousandth
§	Section (usually a section of federal or state rules or statutes)
ADB	assessment database
AU	assessment unit
AWS	agricultural water supply
BAG	Basin Advisory Group
BLM	United States Bureau of Land Management
BMP	best management practice
BOD	biochemical oxygen demand
BOR	United States Bureau of Reclamation
Btu	British thermal unit
BURP	Beneficial Use Reconnaissance Program
C	Celsius
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
cfs	cubic feet per second
cm	centimeters
CWA	Clean Water Act
CWAL	cold water aquatic life
CWE	cumulative watershed effects
DEQ	Department of Environmental Quality
DO	dissolved oxygen
DOI	U.S. Department of the Interior
DWS	domestic water supply
EMAP	Environmental Monitoring and Assessment Program
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
F	Fahrenheit
FPA	Idaho Forest Practices Act
FWS	U.S. Fish and Wildlife Service
GIS	Geographical Information Systems
HUC	Hydrologic Unit Code
I.C.	Idaho Code
IDAPA	Refers to citations of Idaho administrative rules
IDFG	Idaho Department of Fish and Game

IDL Idaho Department of Lands

IDWR Idaho Department of Water Resources

INFISH the federal Inland Native Fish Strategy

IRIS Integrated Risk Information System

km kilometer

km^2 square kilometer

LA load allocation

LC load capacity

m meter

m^3 cubic meter

mi mile

mi^2 square miles

MBI Macroinvertebrate Biotic Index

MGD million gallons per day

mg/L milligrams per liter
mm millimeter

MOS margin of safety

MRCL multiresolution land cover

MWMT maximum weekly maximum temperature

n.a. not applicable

NA not assessed

NB natural background

nd no data (data not available)

NFS not fully supporting

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NTU nephelometric turbidity unit

ORV off-road vehicle

ORW Outstanding Resource Water

PACFISH the federal Pacific Anadromous Fish Strategy

PCR primary contact recreation

PFC proper functioning condition

ppm part(s) per million

QA quality assurance

QC quality control

RBP rapid bioassessment protocol

RDI DEQ’s River Diatom Index

RFI DEQ’s River Fish Index

RHCA riparian habitat conservation area

RMI DEQ’s River Macroinvertebrate Index

RPI DEQ’s River Physiochemical Index

SBA subbasin assessment

SCR secondary contact recreation

SFI DEQ's Stream Fish Index

SHI DEQ's Stream Habitat Index

SMI DEQ's Stream Macroinvertebrate Index

SRP soluble reactive phosphorus

SS salmonid spawning

SSOC stream segment of concern

STATSGO State Soil Geographic Database

TDG total dissolved gas

TDS total dissolved solids

T&E threatened and/or endangered species

TIN total inorganic nitrogen

TKN total Kjeldahl nitrogen

TMDL total maximum daily load

TP total phosphorus

TS total solids

TSS total suspended solids

t/y tons per year

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USDI United States Department of the Interior

USFS United States Forest Service

USGS United States Geological Survey

WAG Watershed Advisory Group

WBAG *Water Body Assessment Guidance*

WBID water body identification number

WET whole effluence toxicity

WLA wasteload allocation

WQLS water quality limited segment

WQMP water quality management plan

WQRP water quality restoration plan

WQS water quality standard

Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

This document addresses the water bodies in the upper Hangman Creek portion of the Hangman Creek Subbasin that have been placed on Idaho's current §303(d) list.

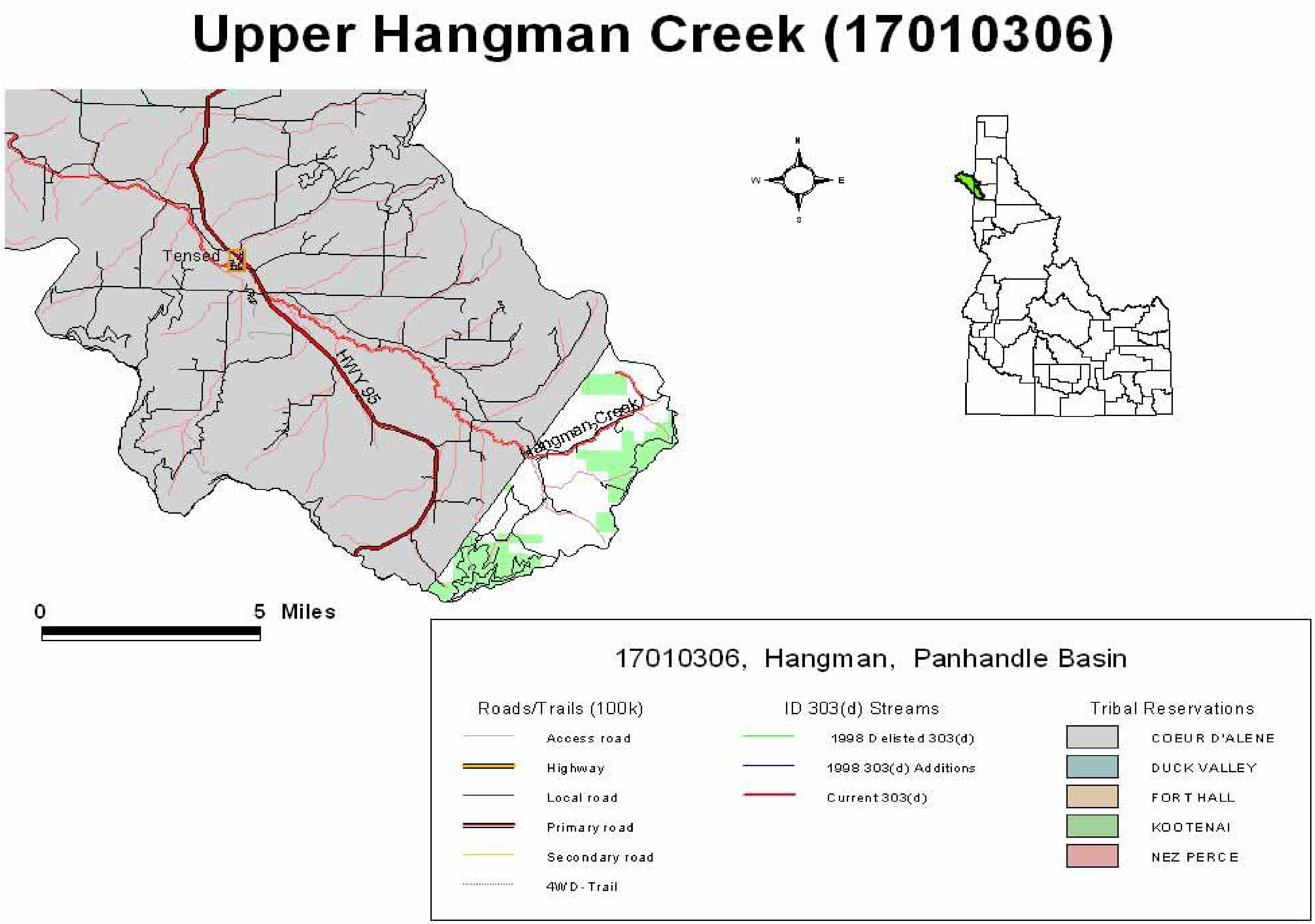
This subbasin assessment (SBA) and TMDL analysis have been developed to comply with Idaho's TMDL schedule. The assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the upper Hangman Creek portion of the Subbasin above the Coeur d'Alene Tribe Reservation, located in northern Idaho.

The first part of this document, the SBA, is an important first step in leading to the TMDL. The starting point for this assessment was Idaho's current §303(d) list of water quality limited water bodies. One segment of the Hangman Creek Subbasin above the Coeur d'Alene Tribe Reservation boundary was listed on this list. The SBA examines the current status of §303(d) listed water and defines the extent of impairment and causes of water quality limitation throughout the portion of the subbasin. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

Subbasin at a Glance

The upper Hangman Creek watershed, that portion above the Coeur d'Alene Tribal boundary is where the rolling hills of Hangman Creek valley meet steep mountain sides. This portion of the watershed is primarily forested although there have been some openings created for other land use activities. The land is primarily privately owned with only a smaller amount of National Forest lands. The primary land use is timber harvesting activities with some residential development along major roads and some livestock grazing activity at lower elevations.

Figure A. Upper Hangman Creek Portion of Subbasin 17010306.



Key Findings

- Hangman Creek was listed in 1998 for habitat alteration, sediment, nutrients, and bacteria. Tributaries to Hangman Creek in this portion of the watershed were §303d listed in 2002 for temperature. No TMDL was completed for habitat alteration in accordance with DEQ policy.
- Assessments of BURP monitoring data reveal that all sites failed to support uses including those on tributary streams. Most failures were due to low fish numbers despite good macroinvertebrate and habitat numbers. Fish quality is likely a result of low flow. Failure to support was also due to temperature criteria violations. TMDLs are completed for sediment, bacteria and temperature due to criteria violations and problems in lower Hangman Creek that have been well documented in the past.
- Numeric targets for TMDLs include 80% bank stability and associated streambank erosion for sediment, 90% effective shade for thermal loading, and recreation use *Escherichia coli* criteria for bacteria.
- Loading capacities, existing loads, and load allocations for all three pollutants are seen in Tables 9 through 16 of this document. Reductions in streambank erosion of sediment vary from 9% in upper South Fork (SF) Hangman Creek to 73% at the lowest reaches of Hangman Creek and its South Fork. Bacteria load reductions in Hangman Creek and SF Hangman Creek vary considerably through time and range from 15% to 85%. Percent reductions in summer solar load vary from 15% in Bunnel Creek to 70% in SF Hangman Creek. A 10% margin of safety was removed from the loading capacity for sediment and bacteria prior to allocation. The potential natural vegetation approach to solar load analysis has an implicit margin of safety.
- Although §303(d) listed for nutrients, the upper watershed had decreasing total phosphorus (TP) values as early as 1990. A subsequent sampling effort in the spring of 2005 revealed that TP values in all headwater streams were near ecoregion reference levels. Therefore it is recommended that Hangman Creek above the Tribal boundary be delisted for nutrients.

Table A. Streams and pollutants for which TMDLs were developed.

Stream	Pollutant(s)
Hangman Creek, SF Hangman Creek, Martin Creek, Conrad Creek, Hill Creek, Bunnel Creek	Sediment and Temperature
Hangman Creek and SF Hangman Creek	Bacteria

Table B. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
ID17010306PN001_02	Sediment, Bacteria, Temperature	Yes	Previously only listed for Temperature	2002-2005 data and downstream conditions
ID17010306PN001_03	Sediment, Bacteria, Temperature	Yes	Previously listed for Habitat Alteration, Sediment, Bacteria, and Nutrients	2002-2005 data
ID17010306PN001_03	Nutrients	No	De-list	2005 data

1. Subbasin Assessment – Watershed Characterization

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. (In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.)

This document addresses the water bodies in the upper Hangman Creek Subbasin above the Coeur d'Alene Tribal boundary that have been placed on Idaho's current §303(d) list.

The overall purpose of the subbasin assessment (SBA) and TMDL is to characterize and document pollutant loads within the upper Hangman Creek Subbasin. The first portion of this document, the SBA, is partitioned into four major sections: watershed characterization, water quality concerns and status, pollutant source inventory, and a summary of past and present pollution control efforts (Sections 1 – 4). This information will then be used to develop a TMDL for each pollutant of concern for the upper Hangman Creek Subbasin (Section 5).

1.1 Introduction

In 1972, Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Water Environment Federation 1987, p. 9). The act and the programs it has generated have changed over the years, as experience and perceptions of water quality have changed.

The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to insure "swimmable and fishable" conditions. This goal, along with a 1972 goal to restore and maintain chemical, physical, and biological integrity, relates water quality with more than just chemistry.

Background

The federal government, through the U.S. Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. The Department of Environmental Quality (DEQ) implements the CWA in Idaho, while the EPA oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Section 303 of the CWA requires DEQ to adopt water quality standards and to review those standards every three years (EPA must approve Idaho's water quality standards). Additionally, DEQ must monitor waters to identify those not meeting water quality standards. For those waters not meeting standards, DEQ must establish a TMDL for each pollutant impairing the waters. Further, the agency must set appropriate controls to restore water quality and allow the water bodies to meet their designated uses.

These requirements result in a list of impaired waters, called the "§303(d) list." This list describes water bodies not meeting water quality standards. Waters identified on this list require further analysis. A SBA and TMDL provide a summary of the water quality status and allowable TMDL for water bodies on the §303(d) list. The *Upper Hangman Creek Assessment and TMDL* provides this summary for the currently listed waters in the upper Hangman Creek portion of the Subbasin above the Coeur d'Alene Tribe Reservation boundary.

The SBA section of this document (Sections 1 – 4) includes an evaluation and summary of the current water quality status, pollutant sources, and control actions in the upper Hangman Creek Subbasin to date. While this assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up to date and accurate. The TMDL is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (Water quality planning and management, 40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

Some conditions that impair water quality do not receive TMDLs. The EPA does consider certain unnatural conditions, such as flow alteration, human-caused lack of flow, or habitat alteration, that are not the result of the discharge of a specific pollutants as "pollution." However, TMDLs are not required for water bodies impaired by pollution, but not by specific pollutants. A TMDL is only required when a pollutant can be identified and in some way quantified.

Idaho's Role

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The state may assign or designate beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho water quality standards and include the following:

- Aquatic life support–cold water, seasonal cold water, warm water, salmonid spawning, modified
- Contact recreation–primary (swimming), secondary (boating)
- Water supply–domestic, agricultural, industrial
- Wildlife habitats
- Aesthetics

The Idaho legislature designates uses for water bodies. Industrial water supply, wildlife habitats, and aesthetics are designated beneficial uses for all water bodies in the state. If a water body is unclassified, then cold water and primary contact recreation are used as additional default designated uses when water bodies are assessed.

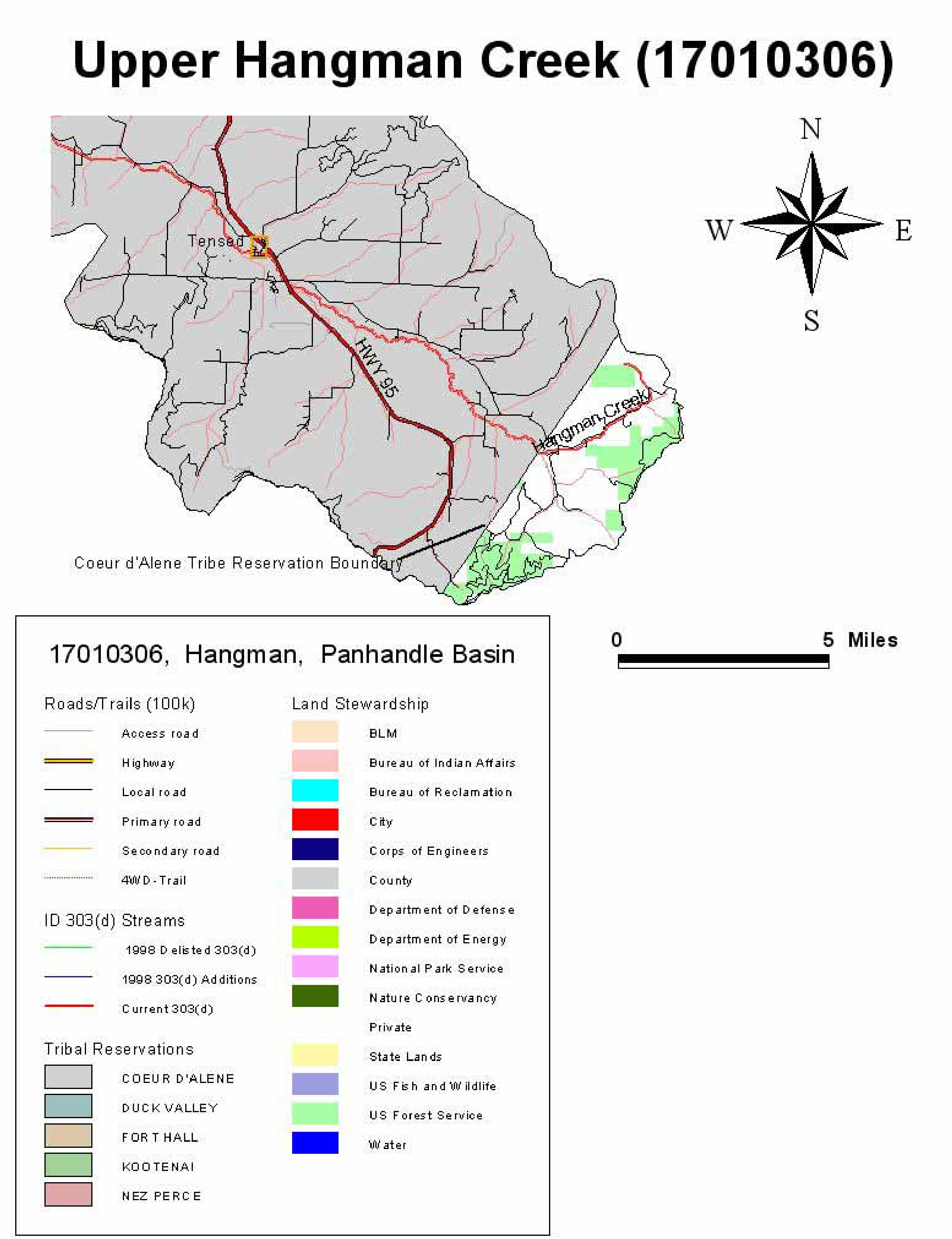
A SBA entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, and landscape data to address several objectives:

- Determine the degree of designated beneficial use support of the water body (i.e., attaining or not attaining water quality standards).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identity and location of pollutant sources.
- Determine the causes and extent of the impairment when water bodies are not attaining water quality standards.

1.2 Physical and Biological Characteristics

The Hangman Creek watershed is approximately 34,803 hectares (86,000 acres) in size situated on the western edge of northern Idaho. Only the headwaters area above the Coeur d'Alene Tribal boundary, an area of about 4,047 hectares (10,000 acres), is addressed in this document (see Figure 1). Hangman Creek originates in a wooded canyon between Charles Butte and West Dennis Mountain (elevation 1465m above sea level), and flows southwest until it joins the South Fork Hangman Creek about 152m above the Coeur d'Alene Tribal boundary. The South Fork Hangman Creek originates at the base of Crane Point and flows north to Hangman Creek. From the confluence with the South Fork, Hangman Creek turns northwest and flows through the Coeur d'Alene Tribe Reservation to the Idaho/Washington border.

Figure 1. Upper Hangman Creek Portion of Subbasin.

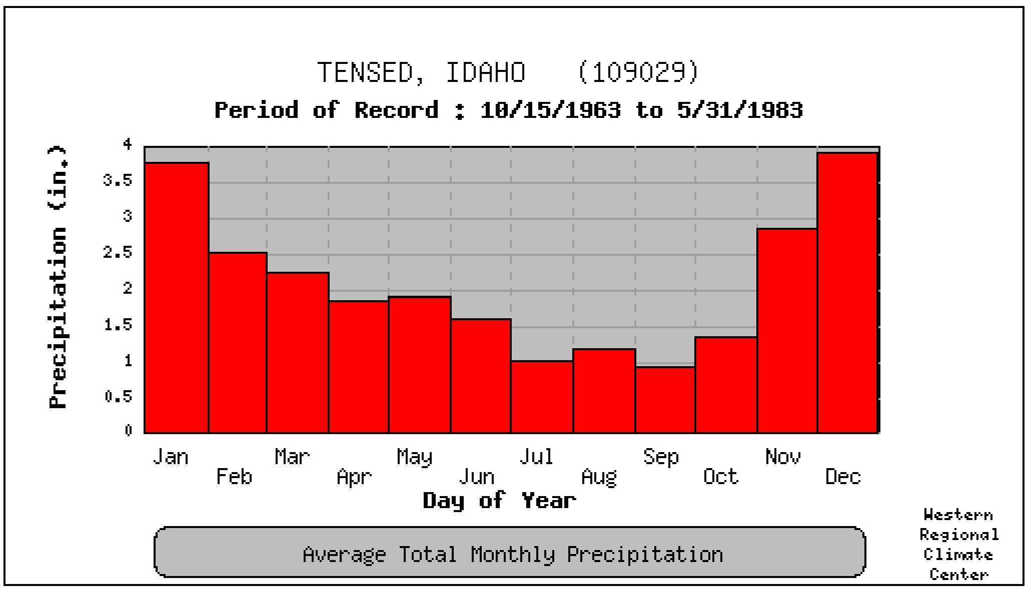


Climate

The climate of the Hangman Creek watershed is one of transition. Precipitation varies considerably from the Palouse region to the mountains. Total annual precipitation is about 20 inches on the northwest edge of the watershed and about 45 inches in the southern mountains. Precipitation can vary 20 inches in nine miles, two inches per mile, and in some cases as much as five inches per mile (BSWCD, 1981). The mountains on the west side of the watershed provide the first relief encountered by westerly winds as they reach the eastern extremities of the Palouse prairie. As the air is uplifted and cooled, a rain shadow results on the east side. The valley shape and arrangement of surrounding mountains also creates a venture effect, which accelerates and cools the air. The combined effects of surface relief and prevailing wind patterns creates a multitude of micro-climates in the watershed (BSWCD, 1981).

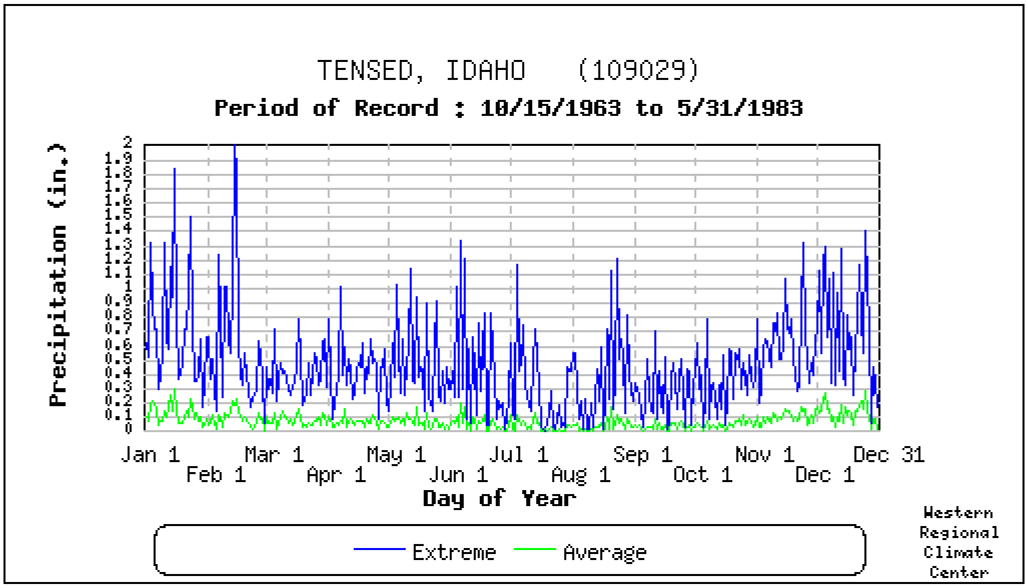
Precipitation is characteristic of cool moist winters and warmer drier summers. Average total monthly precipitation varies from close to four inches in December to as little as one inch in September (Figure 2).

Figure 2. Average Total Monthly Precipitation Measured at Tensed, Idaho from 1963 to 1983.



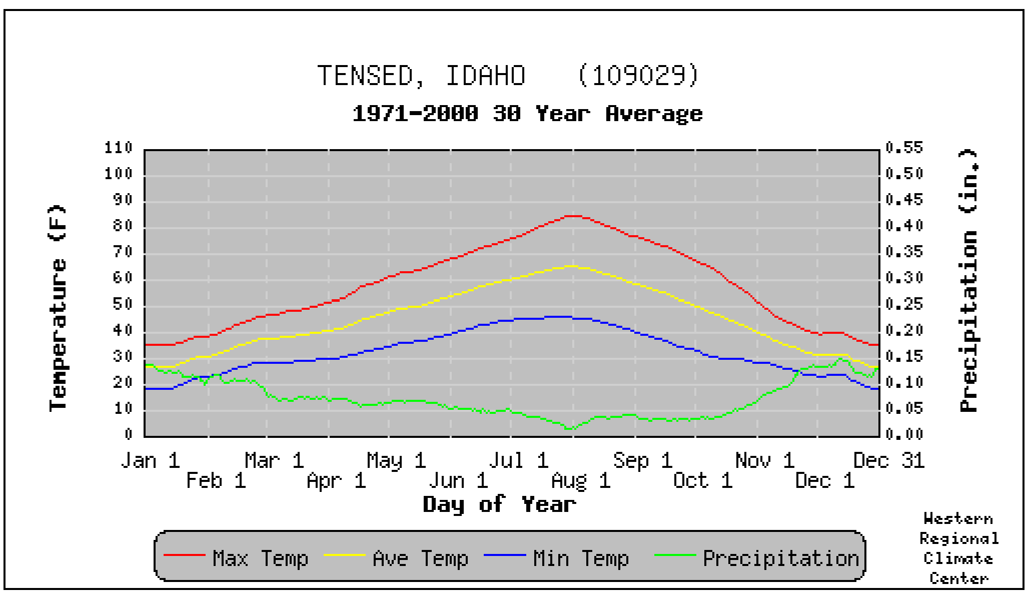
Average daily precipitation intensity is rather even throughout the year with winter days slightly higher at 0.2 to 0.3 inches and the remainder of the year at 0.1 inches (Figure 3). Extreme precipitation events are highly variable with the highest extremes (up to 2 inches) occurring during the months of January and February (Figure 3).

Figure 3. Average and Extreme Daily Precipitation Measured at Tensed, Idaho from 1963 to 1983.



Average temperatures are also single modal with highest average temperatures in August and lowest average temperatures January. Maximum average air temperatures are general below 80^{o}F (Figure 4).

Figure 4. 30 Year Normal (1971-2000) Average, Minimum and Maximum Air Temperatures for Tensed, Idaho.



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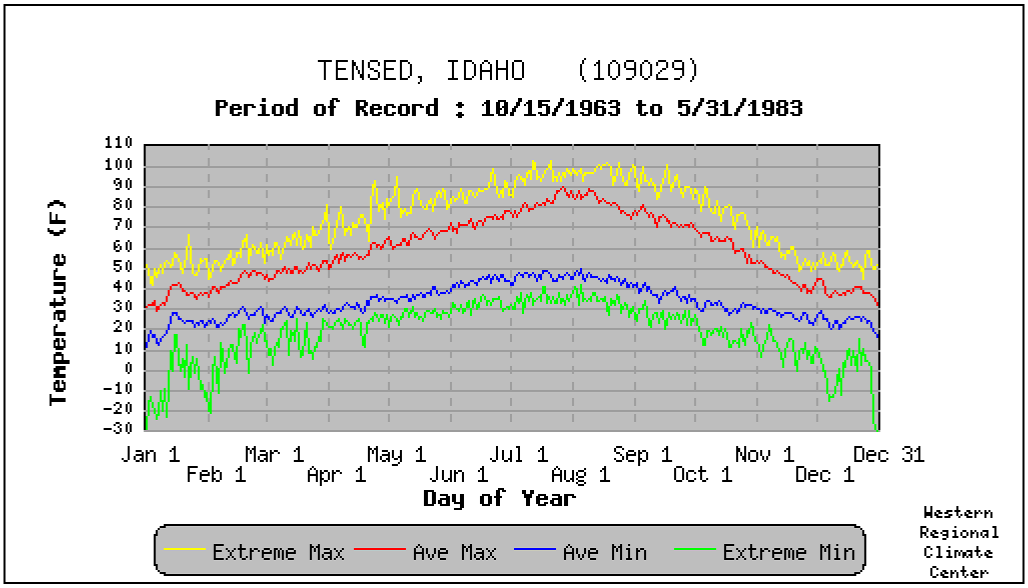
Air temperature extremes on the other hand can exceed 80^{o}F in May and can reach 100^{o}F in July through September (Figure 5).

Figure 5. Extreme and Average Maximum and Minimum Air Temperatures Measured at Tensed, Idaho from 1963 to 1983.



Subbasin Characteristics

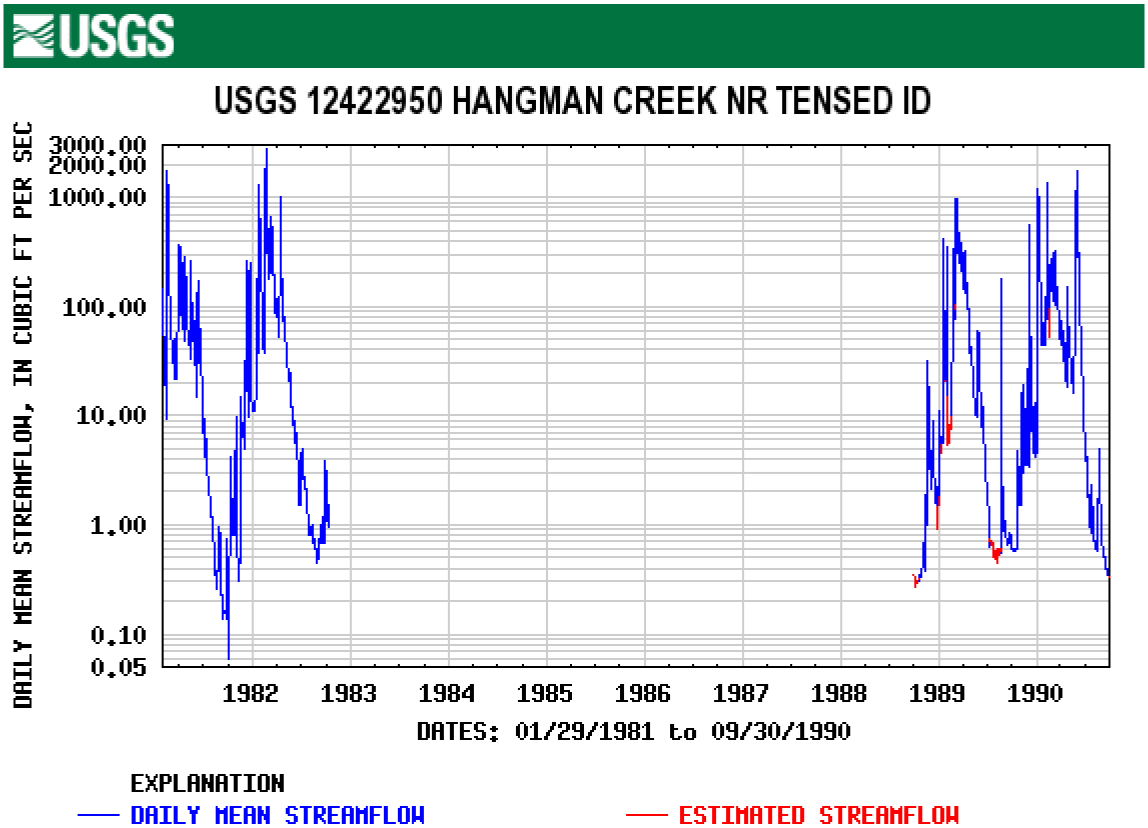
Hydrography

Hangman Creek is part of the Spokane River system with the majority of the watershed in Washington and its headwaters in Idaho. The subbasin in Idaho has the classic dendritic stream pattern with eight major sub-watersheds, including Mission Creek, Sheep Creek, Andrew Springs' Creek, Mineral Creek, Indian Creek, Squaw Creek, Lolo Creek and Hangman Creek (Fortis and Hartz, 1991). The subbasin area in Idaho is approximately 86,000 acres; 53,000 acres are in forest land and 33,000 acres are non-irrigated cropland, hayland and pasture.

Except for the headwaters, which are likely Rosgen (1996) A and B channel types, the majority of the watershed is Rosgen type C4 (IDEQ, 1991). The C4 type stream is characterized by a gradient of 1% or less, moderate sinuosity, a width/depth ratio averaging around 10, and a bottom substrate that is mostly sand/silt with some gravel. Hangman Creek is moderately entrenched with poor valley confinement and very unstable banks of unconsolidated, non-cohesive soils. Hangman Creek below Tensed is particularly prone to flooding and streambank erosion.

Stream flow data is limited for upper Hangman Creek; however, what is available shows an extremely rapid snowmelt dominated system with annual variations in flow from less than 1cfs to 3000cfs (Figure 6). Peak flows occur early, generally before April and low flows occur in late summer. Monthly average and peak flows are highly variable from year to year depending on snow pack, the prevalence of rain-on-snow events and spring rain.

Figure 6. Measured Daily Streamflow for Hangman Creek near Tensed, Idaho from 1981 to 1990.



Geology and/or Soils

The lithology of upper Hangman Creek is rather simple with argillite and slate making up the materials in the mountains and loess filling the valley floor (Figure 7). The derivatives of that lithology include Precambrian light-colored siltite overlying multicolored fine-grained detritus and Pleistocene wind-blown loess of northern Idaho (Figure 8). Soil units in the headwaters of Hangman Creek proper include Pinecreek-Ahrs-Honeyjones and Reggear-Clarkia-Agatha (Figure 9). Elsewhere throughout the upper watershed are Taney-Cald and Santa-Taney-Moctileme soil units. The predominant soil unit along Hangman Creek below the confluence with the South Fork is Latahco-Cald-Moctileme soils.

Taney and Santa soils are very deep, undulating to hilly or steep, slowly permeable, moderately well drained silt loams on loess-covered hills (Weisel, 1980). These soils can have perched water tables in spring and be prone to flooding and high erodibility. Latahco-Cald-Moctileme soils are also very deep and moderately slowly permeable, but are somewhat poorly drained resulting in flooding and wetness in spring which may limit farming.

Figure 7. Hangman Creek Lithology.

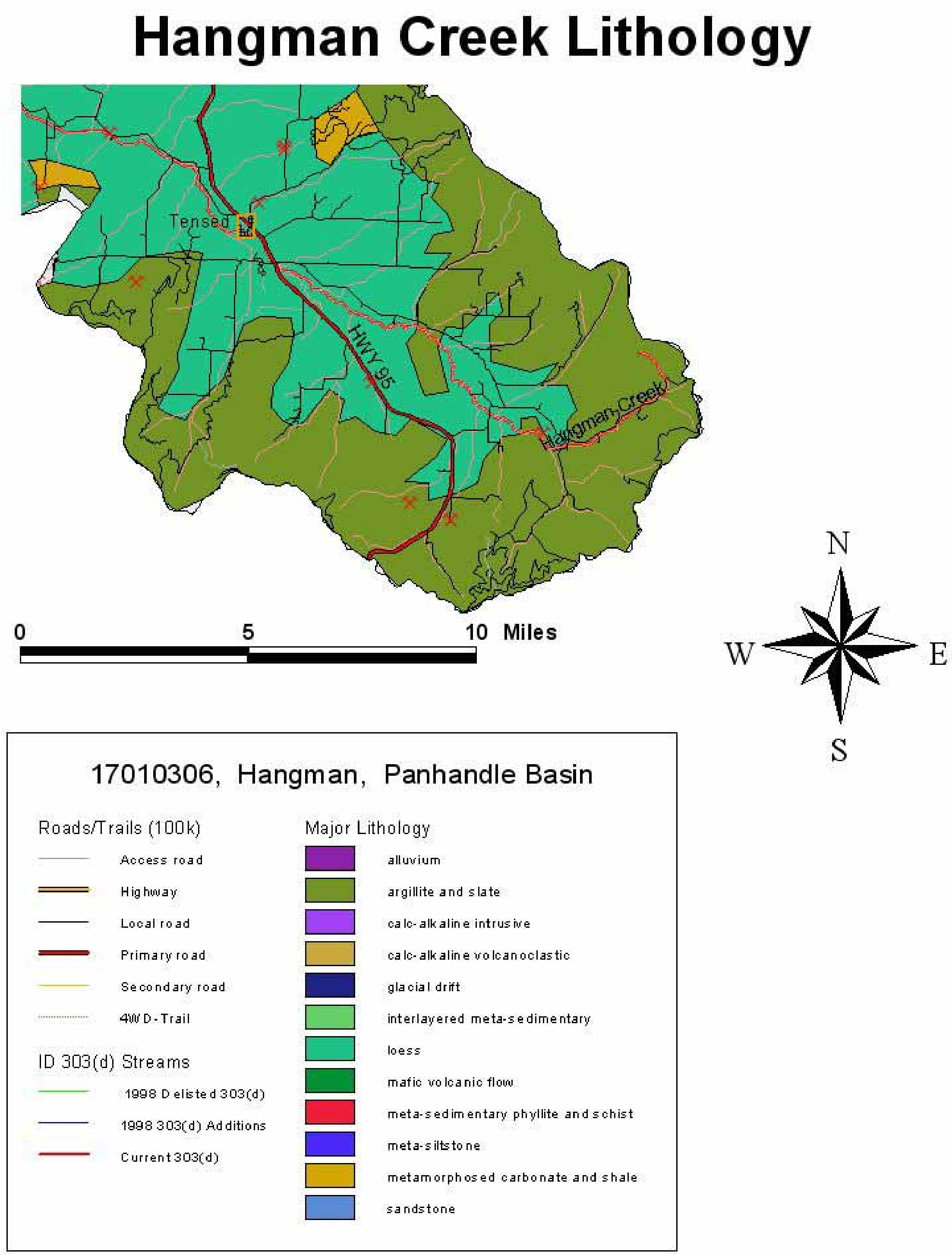


Figure 8. Hangman Creek Geology.

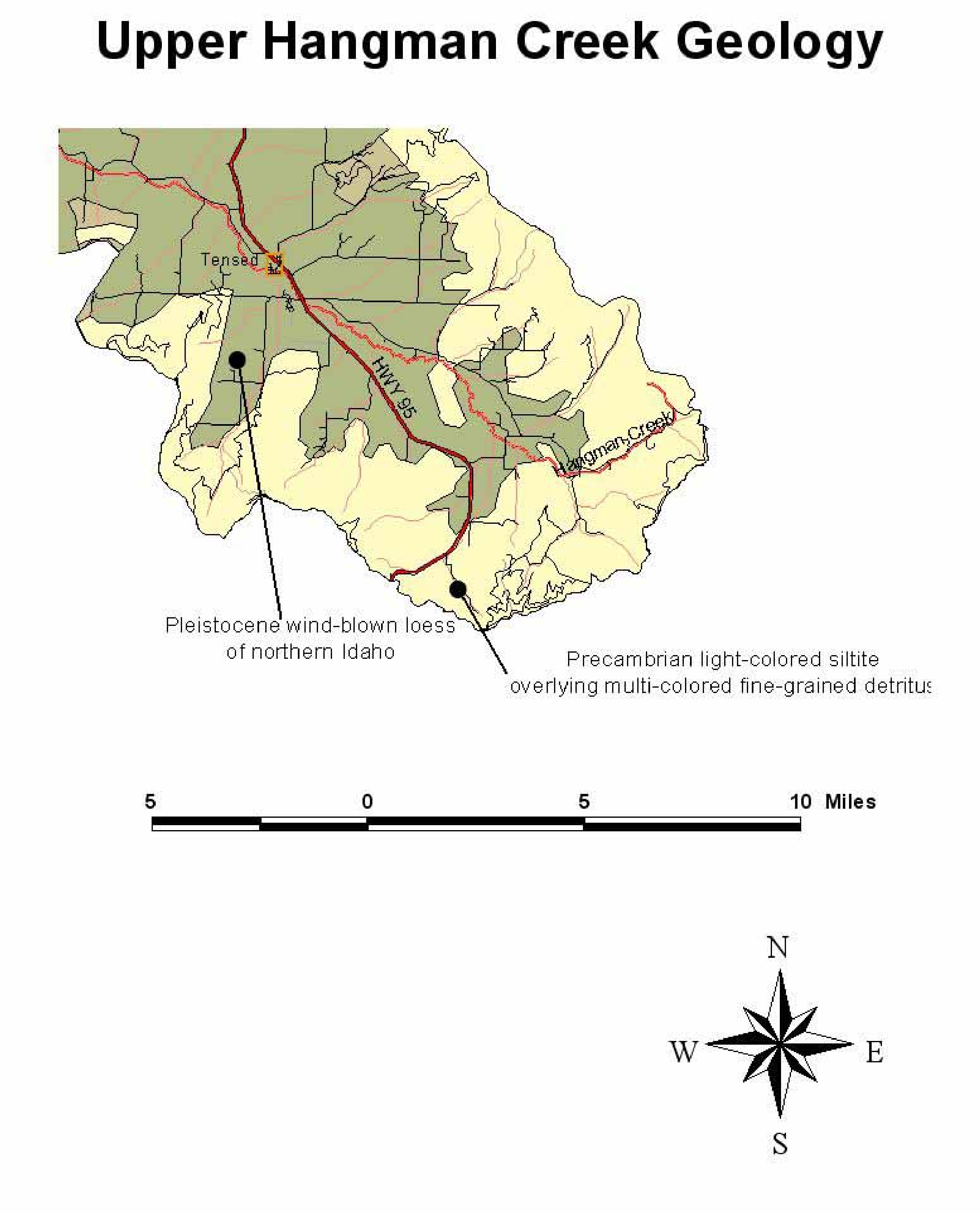
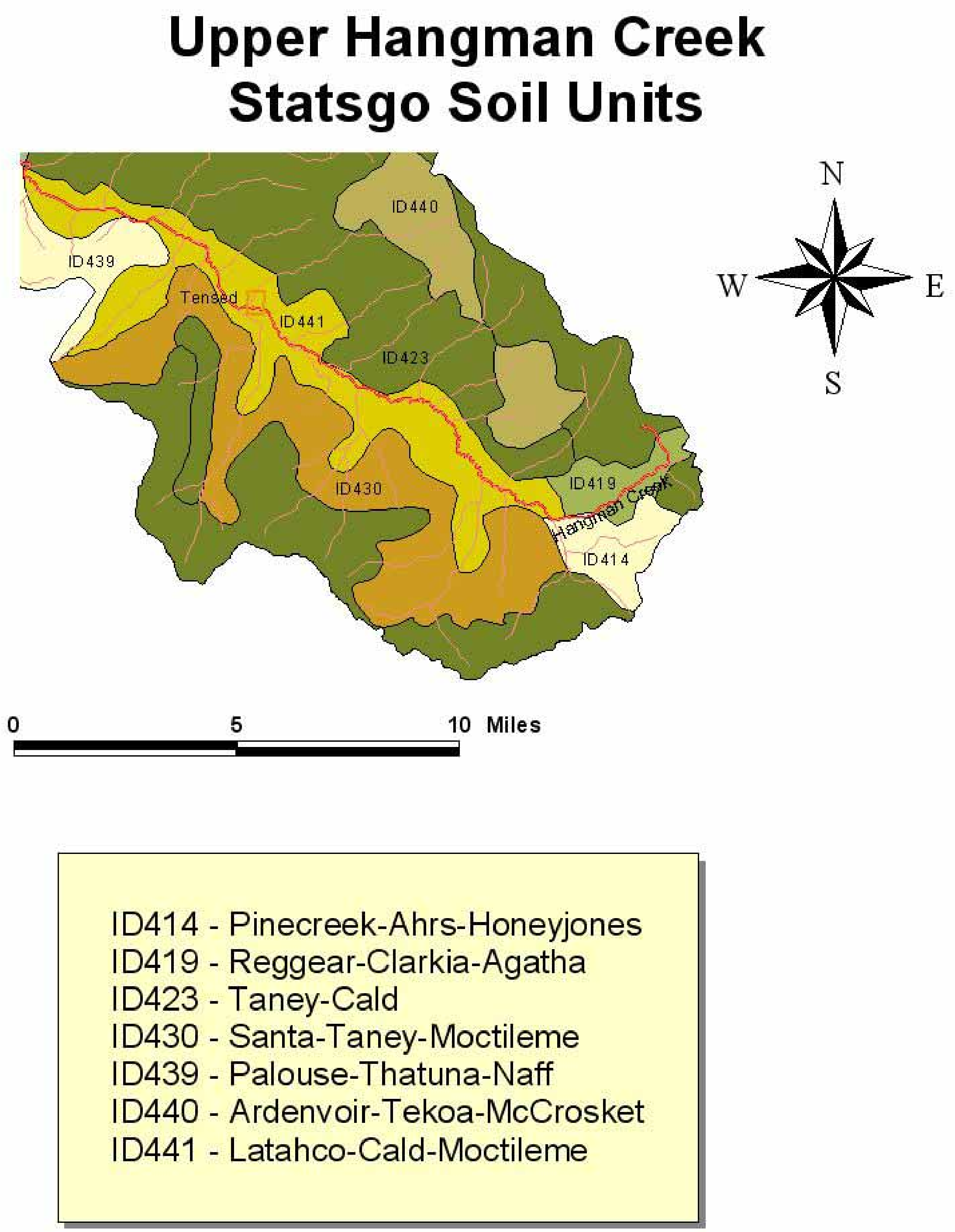


Figure 9. Hangman Creek Soils.



A major portion of upper Hangman Creek above the confluence with its South Fork is overlain with Pinecreek-Ahrs-Honeyjones and Reggear-Clarkia-Agatha soil groups. On the south side of Hangman Creek proper, the Pinecreek-Ahrs-Honeyjones group consists of very deep, well drained soils on mountains (NRCS, 2001). They formed in material weathered from metasedimentary rock with a thick mantle of volcanic ash. Pinecreek soils are on south-facing mountain slopes at elevations from 2,200 to 4000 feet. Ahrs soils are on east and west-facing mountain slopes and are loamy-skeletal with an ochric epipedon. Honeyjones soils also have an ochric epipedon but are on north-facing slopes.

On the north side of Hangman Creek is the Reggear-Clarkia-Agatha group, consisting of a more variable soils. The Reggear series consists of moderately deep to fragipan, moderately well-drained soils on mountain slopes or hills on basalt plateaus. The Clarkia series consists of very deep poorly drained soils on floodplains, valley floors, and low stream terraces. They formed in mixed alluvium and permeability is moderately slow. Agatha soils are deep and well drained on benches, escarpments, and canyon sides. They formed in colluvium or residuum weathered from basalt with a loess mantle.

<u>Topography</u>

In general, the topography is undulating and hilly typical of the Palouse region. Headwaters areas are increasing in steepness as streams originate in surrounding mountains. The headwaters of Hangman Creek originate near mountains of 4300-4800 feet in elevation and decrease to almost 2700 feet at the Coeur d'Alene Tribal boundary. The South Fork Hangman Creek originates near 3300 feet in elevation.

<u>Vegetation</u>

The upper Hangman Creek watershed is where Palouse hills meet northern Idaho hills and low relief mountains. Palouse hills were once dominated by fescue-wheatgrass grasslands that have largely been converted agriculture (wheat, peas, beans and rapeseed). The northern Idaho hills and low relief mountains of the Northern Rockies ecoregion contain productive forests on deep rich soils. The dominant trees include grand fir, western redcedar, Douglas fir, and Ponderosa pine.

<u>Fisheries and Aquatic Fauna</u>

The following species were captured in 1963 by Coeur d'Alene Tribe personnel in upper Hangman Creek: rainbow trout, eastern brook trout, speckled dace, longnose dace, longnose sucker, northern pikeminnow, chiselmouth, redside shiner, brown bullhead, and tench (WDOE & SCCD, 1994). Water quality work in the 1980s and 1990s reported that catfish, redside shiners, and dace were the primary constituents of the Hangman Creek fishery (SCS, 1994). The creek also supported rainbow trout in the headwaters and in several isolated sections of lower Hangman Creek in the State of Washington at that time. Sculpin have also been observed in the upper watershed by IDFG personnel.

Idaho Department of Environmental Quality BURP crews in 2002 observed a number of frogs and small fish in the upper watershed. BURP electrofishing activities resulted in the capture of speckled dace, redside shiner and rainbow trout in Hangman Creek below the South Fork Hangman Creek confluence; sucker, rainbow trout, redside shiner, and speckled dace at the mouth of South Fork Hangman Creek; and rainbow trout in Bunnel Creek.

Aquatic fauna probably include amphibians such as Columbia spotted frog, typical furbearers (muskrat, mink, and beaver), waterfowl, and a host of birds and other animals living or visiting from nearby uplands.

Subwatershed Characteristics

Only the headwaters area of Hangman Creek, that portion above the Coeur d'Alene Tribe Reservation Boundary, is considered in this subbasin assessment. Included in this discussion are:

- Hangman Creek from its headwaters to approximately 500 feet below the confluence with the South Fork Hangman Creek,
- Tributaries to upper Hangman Creek including Bunnel Creek and Hill Creek,
- South Fork Hangman Creek,
- Tributaries to South Fork Hangman Creek including Conrad Creek, Martin Creek, and Papoose Creek.

Stream Characteristics

Hangman Creek and South Fork Hangman Creek are second order streams, both of which are predominantly Rosgen B channel type in their headwaters and C or F channels at lower elevations. Gradients at the lower ends of these streams are generally 1% or greater. Both are trough-like valley types with generally low sinuosity. Both streams are generally 3m wide with width/depth ratios near 10.

Bunnel Creek is first order, Rosgen B channel type with about 2% gradient near its mouth. It is moderately sinuous, but with a flat bottom valley type. This stream is less than 2m wide but has width/depth ratios near 11, reflecting a very shallow system. The timber harvested section of upper Bunnel Creek has a braided channel.

Martin Creek is a first order, moderately sinuous stream with Rosgen C channel type and a gradient of 1.5% near its mouth. Channel widths were less than 3m and width/depth ratios were less than 10.

1.3 Cultural Characteristics

Most of this portion of upper Hangman Creek watershed is private land with very small portions of Hill Creek, Conrad Creek, Martin Creek, and South Fork Hangman Creek in National Forest ownership. The predominant land use activity is timber harvesting with some grazing on small pastures along stream valleys and a small amount of residential development.

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2. Subbasin Assessment – Water Quality Concerns and Status

Water quality problems in the Hangman Creek subbasin have been monitored and documented since at least 1980 (BSWCD, 1981; Bauer and Wilson, 1983; Fortis and Hartz, 1991; SCS, 1994; WDOE and SCCD, 1994). The subbasin as a whole has experienced impacts from altered hydrology, rain on snow events, erosion from cropland fields, and streambank erosion. Substantial work has already been done in the watershed through BMP planning and implementation to address some of these impacts. This assessment and TMDL addresses only that section of the Hangman Creek subbasin above the Coeur d'Alene Tribal boundary.

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

Hangman Creek above the Tribal boundary was listed on the Idaho 1998 §303d list of impaired waters for habitat alteration, nutrient, and sediment pollution. The remainder of Hangman Creek in Idaho from the Tribal boundary to the Washington state line was listed on that 303d list for bacteria, nutrients, and sediment pollutants. The court ordered schedule for completion of TMDLs for waters listed on that 1998 list, indicates that the Hangman Creek TMDLs are to be completed in 2005.

Water body assessments that examined BURP and other data and completed by DEQ in 2002 determined that the assessment unit #ID17010306PN001_02 (which includes tributaries to Hangman Creek and Hangman Creek proper above its confluence with the South Fork Hangman Creek) was impacted by temperature. Assessment unit #ID17010306PN001_03 (mainstem Hangman Creek below the confluence with South Fork Hangman Creek) was determined to be impacted by bacteria, sediment, and nutrient pollutants.

Bacteria data collected by DEQ in 2002 subsequent to the 2002 assessment process showed violations of bacteria criteria for recreation uses in Hangman Creek and South Fork Hangman Creek above the Tribal boundary. Although not listed for bacteria, Hangman Creek above the South Fork confluence will receive a TMDL for bacteria pollution as well.

Section 303(d) of the CWA states that waters that are unable to support their beneficial uses and that do not meet water quality standards must be listed as water quality limited waters. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

<u>About Assessment Units</u>

Assessment units (AUs) now define all the waters of the state of Idaho. These units and the methodology used to describe them can be found in the WBAGII (Grafe et al 2002).

AUs are groups of similar streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs—although ownership and land use can change significantly, the AU remains the same.

Using assessment units to describe water bodies offers many benefits, the primary benefit being that all the waters of the state are now defined consistently. In addition, using AUs fulfills he fundamental requirement of EPA's 305(b) report, a component of the Clean Water Act wherein states report on the condition of all the waters of the state. Because AUs are a subset of water body identification numbers, there is now a direct tie to the water quality standards for each AU, so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

However, the new framework of using AUs for reporting and communicating needs to be reconciled with the legacy of 303 (d) listed streams. Due to the nature of the court-ordered 1994 §303(d) listings, and the subsequent 1998 §303(d) list, all segments were added with boundaries from "headwater to mouth." In order to deal with the vague boundaries in the listings, and to complete TMDLs at a reasonable pace, DEQ set about writing TMDLs at the watershed scale (HUC), so that all the waters in the drainage are and have been considered for TMDL purposes since 1994.

The boundaries from the 1998 §303(d) listed segments have been transferred to the new AU framework, using an approach quite similar to how DEQ has been writing SBAs and TMDLs. All AUs contained in the listed segment were carried forward to the 2002 303(d) listings in Section 5 of the Integrated Report. AUs not wholly contained within a previously listed segment, but partially contained (even minimally), were also included on the 303(d) list. This was necessary to maintain the integrity of the 1998 §303(d) list and to maintain continuity with the TMDL program. These new AUs will lead to better assessment of water quality listing and de-listing.

When assessing new data that indicate full support, only the AU that the monitoring data represents will be removed (de-listed) from the 303(d) list (Section 5 of the Integrated Report.).

Listed Waters

Table 1shows the pollutants listed and the basis for listing for each §303(d) listed AU in the examined portion of the subbasin. Not all of the water bodies will require a TMDL, as will be discussed later. However, a thorough investigation, using the available data, was performed before this conclusion was made. This investigation, along with a presentation of the evidence of non-compliance with standards for several other tributaries, is contained in the following sections.

Table 1. §303(d) Segments in the Upper Hangman Creek portion of the Subbasin.

Water Body Name	Assessment Unit ID Number	(year) §303(d) Boundaries	Pollutants	Listing Basis
Hangman Creek	ID17010306PN001_02 ID17010306PN001_03	(1998) above Tribal boundary	Habitat alteration, bacteria, nutrients, sediment	1998 Court ordered listing
Hangman Creek	ID17010306PN001_02	(2002) above South Fork confluence	Temperature	DEQ assessments

2.2 Applicable Water Quality Standards

Hangman Creek from its source to the Washington state line has been designated in the Idaho Water Quality Standards for cold water aquatic life and secondary contact recreation (IDAPA 58.01.02.110.13.P-1). Tributaries to Hangman Creek above the Tribal boundary, including South Fork Hangman Creek, Conrad Creek, Martin Creek, Papoose Creek, Hill Creek, and Bunnel Creek, are undesignated waters and as such are presumed to have cold water aquatic life and secondary contact recreation uses. Because of the documented presence of salmonids since 1975, primarily rainbow trout, it is assumed that this headwaters area of Hangman Creek and associated tributaries have salmonid spawning as an existing use.

Beneficial Uses

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described in the following paragraphs. The *Water Body Assessment Guidance*, second edition (Grafe et al. 2002) gives a more detailed description of beneficial use identification for use assessment purposes.

Existing Uses

Existing uses under the CWA are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards." The existing in-stream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.050.02, .02.051.01, and .02.053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that could support salmonid spawning, but salmonid spawning is not occurring due to other factors, such as dams blocking migration.

Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing uses).

Presumed Uses

In Idaho, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. These undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric cold water criteria and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen, temperature). However, if for example, cold water aquatic life is not found to be an existing use, an use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Hangman Creek from its source to the Washington state line is designated in the Idaho water quality standards for cold water aquatic life and secondary contact recreation (Table 2). Based on the presence of rainbow trout in the upper reaches of Hangman Creek, it is assumed that salmonid spawning is an existing use in the waters addressed in this subbasin assessment and TMDL.

Table 2. Upper Hangman Creek portion of Subbasin beneficial uses of §303(d) listed streams.

Water Body	Uses[a]	Type of Use
Hangman Creek	Cold water aquatic life Secondary contact recreation	Designated Uses
Hangman Creek	Salmonid spawning	Existing Use

[a] CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, AWS – agricultural water supply, DWS – domestic water supply

Table 3. Upper Hangman Creek portion of Subbasin beneficial uses of assessed, non-§303(d) listed streams.

Water Body	Uses[a]	Type of Use
Tributaries to Hangman Creek	Cold water aquatic life Secondary contact recreation	Presumed Uses
Tributaries to Hangman Creek	Salmonid spawning	Existing Use

[a] CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, AWS – agricultural water supply, DWS – domestic water supply

Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250) (Table 4).

Excess sediment is described by narrative criteria (IDAPA 58.01.02.200.08): “Sediment shall not exceed quantities specified in Sections 250 and 252 or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350.”

Narrative criteria for excess nutrients are described in IDAPA 58.01.02.200.06, which states: “Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.”

Narrative criteria for floating, suspended, or submerged matter are described in IDAPA 58.01.02.200.05, which states: “Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities.”

DEQ’s procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the Water Body Assessment Guidance (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

Table 4 includes the most common numeric criteria used in TMDLs.

Figure 10 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

Table 4. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.

Designated and Existing Beneficial Uses				
Water Quality Parameter	**Primary Contact Recreation**	**Secondary Contact Recreation**	**Cold Water Aquatic Life**	**Salmonid Spawning (During Spawning and Incubation Periods for Inhabiting Species)**
Water Quality Standards: IDAPA 58.01.02.250				
Bacteria, ph, and Dissolved Oxygen	Less than 126 *E. coli*/100 ml[a] as a geometric mean of five samples over 30 days; no sample greater than 406 *E. coli* organisms/100 ml	Less than 126 *E. coli*/100 ml as a geometric mean of five samples over 30 days; no sample greater than 576 *E. coli*/100 ml	pH between 6.5 and 9.0 DO[b] exceeds 6.0 mg/L[c]	pH between 6.5 and 9.5 Water Column DO: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater Intergravel DO: DO exceeds 5.0 mg/L for a one day minimum and exceeds 6.0 mg/L for a seven day average
Tempera-ture[d]			22 °C or less daily maximum; 19 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average Bull trout: not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June – August; not to exceed 9 °C daily average in September and October
			Seasonal Cold Water: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	
Turbidity			Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days.	
Ammonia			Ammonia not to exceed calculated concentration based on pH and temperature.	

Designated and Existing Beneficial Uses				
Water Quality Parameter	**Primary Contact Recreation**	**Secondary Contact Recreation**	**Cold Water Aquatic Life**	**Salmonid Spawning (During Spawning and Incubation Periods for Inhabiting Species)**
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131				
Tempera-ture				7 day moving average of 10 °C or less maximum daily temperature for June - September

[a] *Escherichia coli* per 100 milliliters
[b] dissolved oxygen
[c] milligrams per liter
[d] Temperature Exemption - Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the seven-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.
[e] Nephelometric turbidity units

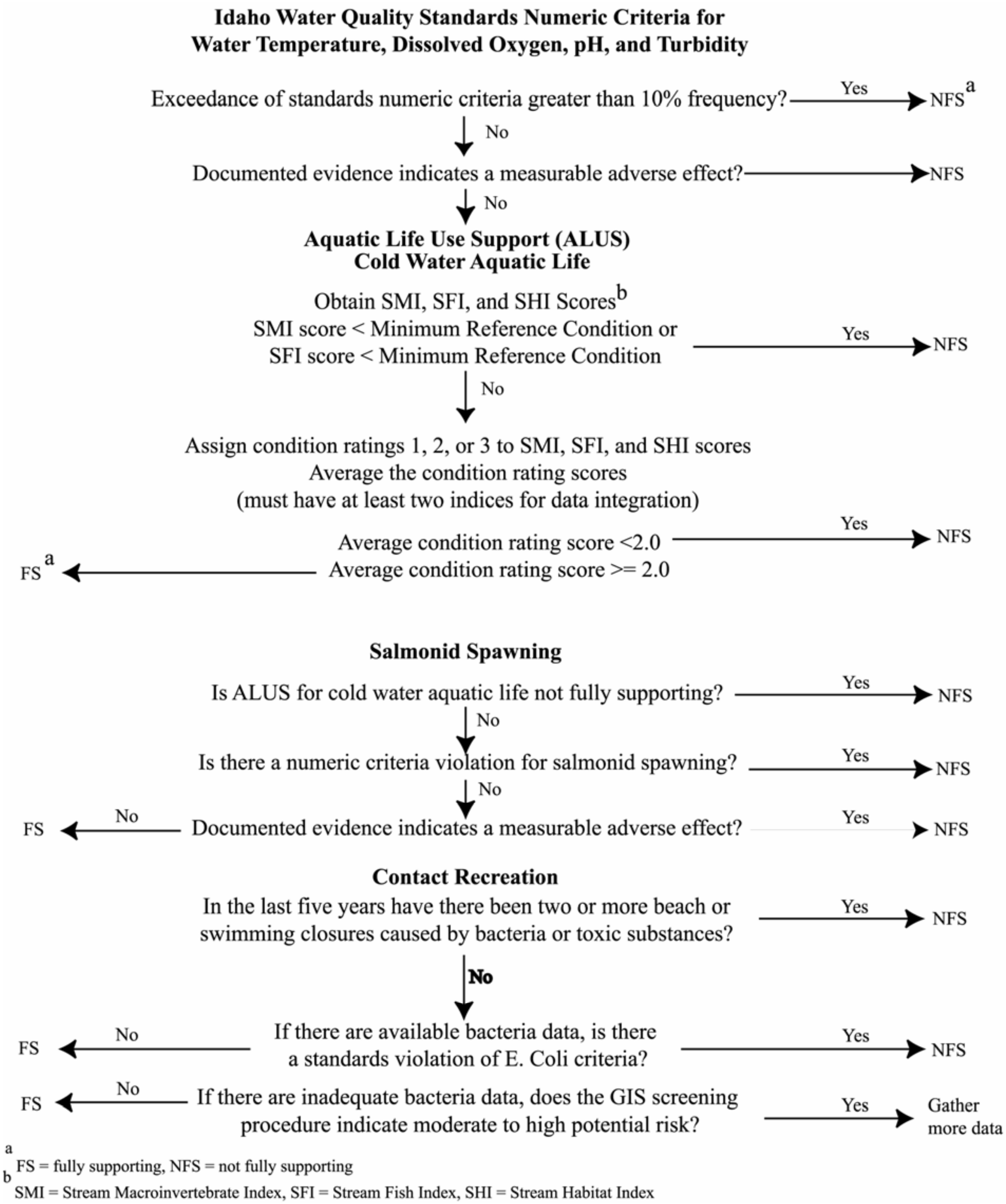

Figure 10. Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: *Water Body Assessment Guidance*, Second Addition (Grafe *et al*. 2002)

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in streams are naturally occurring stream characteristics that have been altered by humans. That is, streams naturally have sediment, nutrients, and the like, but when anthropogenic sources cause these to reach unnatural levels, they are considered "pollutants" and can impair the beneficial uses of a stream.

Temperature

Temperature is a water quality factor integral to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or coldwater aquatic community is present. Many factors, natural and anthropogenic, affect stream temperatures. Natural factors include altitude, aspect, climate, weather, riparian vegetation (shade), and channel morphology (width and depth). Human influenced factors include heated discharges (such as those from point sources), riparian alteration, channel alteration, and flow alteration.

Elevated steam temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low dissolved oxygen or poor food supply. Acceptable temperature ranges vary for different species of fish, with cold water species being the least tolerant of high water temperatures. Temperature as a chronic stressor to adult fish can result in reduced body weight, reduced oxygen exchange, increased susceptibility to disease, and reduced reproductive capacity. Acutely high temperatures can result in death if they persist for an extended length of time. Juvenile fish are even more sensitive to temperature variations than adult fish, and can experience negative impacts at a lower threshold value than the adults, manifesting in retarded growth rates. High temperatures also affect embryonic development of fish before they even emerge from the substrate. Similar kinds of affects may occur to aquatic invertebrates, amphibians and mollusks, although less is known about them.

Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to stream purification. Dissolved oxygen (DO) is the concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. While air contains approximately 20.9% oxygen gas by volume, the proportion of oxygen dissolved in water is about 35%, because nitrogen (the remainder) is less soluble in water. Oxygen is considered to be moderately soluble in water. A complex set of physical conditions that include atmospheric and hydrostatic pressure, turbulence, temperature, and salinity affect the solubility.

Dissolved oxygen levels of 6 mg/L and above are considered optimal for aquatic life. When DO levels fall below 6 mg/L, organisms are stressed, and if levels fall below 3 mg/L for a prolonged period, these organisms may die; oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Dissolved oxygen levels below 1 mg/L are often referred to as hypoxic; anoxic conditions refer to those situations where there is no measurable DO.

Juvenile aquatic organisms are particularly susceptible to the effects of low DO due to their high metabolism and low mobility (they are unable to seek more oxygenated water). In addition, oxygen is necessary to help decompose organic matter in the water and bottom sediments. Dissolved oxygen reflects the health or the balance of the aquatic ecosystem.

Oxygen is produced during photosynthesis and consumed during plant and animal respiration and decomposition. Oxygen enters water from photosynthesis and from the atmosphere. Where water is more turbulent (e.g., riffles, cascades), the oxygen exchange is greater due to the greater surface area of water coming into contact with air. The process of oxygen entering the water is called aeration.

Water bodies with significant aquatic plant communities can have significant DO fluctuations throughout the day. An oxygen sag will typically occur once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. As flows decrease, the amount of aeration typically decreases and the instream temperature increases, resulting in decreased DO. Channels that have been altered to increase the effectiveness of conveying water often have fewer riffles and less aeration. Thus, these systems may show depressed levels of DO in comparison to levels before the alteration. Nutrient enriched waters have a higher biochemical oxygen demand due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand results in lower instream DO levels.

Sediment

Both suspended (floating in the water column) and bedload (moves along the stream bottom) sediment can have negative effects on aquatic life communities. Many fish species can tolerate elevated suspended sediment levels for short periods of time, such as during natural spring runoff, but longer durations of exposure are detrimental. Elevated suspended sediment levels can interfere with feeding behavior (difficulty finding food due to visual impairment), damage gills, reduce growth rates, and in extreme cases eventually lead to death.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on streams and estuaries. For rainbow trout, physiological stress, which includes reduced feeding rate, is evident at suspended sediment concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species, although the data sets are less reliable. Adverse effects on habitat, especially spawning and rearing habitat presumably from sediment deposition, were noted at similar concentrations of suspended sediment.

Organic suspended materials can also settle to the bottom and, due to their high carbon content, lead to low intergravel DO through decomposition.

In addition to these direct effects on the habitat and spawning success of fish, detrimental changes to food sources may also occur. Aquatic insects, which serve as a primary food source for fish, are affected by excess sedimentation. Increased sedimentation leads to a macroinvertebrate community that is adapted to burrowing, thereby making the macroinvertebrates less available to fish. Community structure, specifically diversity, of the aquatic macroinvertebrate community is diminished due to the reduction of coarse substrate habitat.

Settleable solids are defined as the volume (milliliters [ml]) or weight (mg) of material that settles out of a liter of water in one hour (Franson et al. 1998). Settleable solids may consist of large silt, sand, and organic matter. Total suspended solids (TSS) are defined as the material collected by filtration through a 0.45 µm (micrometer) filter (Standard Methods 1975, 1995). Settleable solids and TSS both contain nutrients that are essential for aquatic plant growth. Settleable solids are not as nutrient rich as the smaller TSS, but they do affect river depth and substrate nutrient availability for macrophytes. In low flow situations, settleable solids can accumulate on a stream bottom, thus decreasing water depth. This increases the area of substrate that is exposed to light, facilitating additional macrophyte growth.

Bacteria

Escherichia coli or E. coli, a species of fecal coliform bacteria, is used by the state of Idaho as the indicator for the presence of pathogenic microorganisms. Pathogens are a small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa), which, if taken into the body through contaminated water or food, can cause sickness or even death. Some pathogens are also able to cause illness by entering the body through the skin or mucous membranes.

Direct measurement of pathogen levels in surface water is difficult because pathogens usually occur in very low numbers and analysis methods are unreliable and expensive. Consequently, indicator bacteria which are often associated with pathogens, but which generally occur in higher concentrations and are thus more easily measured, are assessed.

Coliform bacteria are unicellular organisms found in feces of warm-blooded animals such as humans, domestic pets, livestock, and wildlife. Coliform bacteria are commonly monitored as part of point source discharge permits (National Pollution Discharge Elimination System [NPDES] permits), but may also be monitored in nonpoint source arenas. The human health effects from pathogenic coliform bacteria range from nausea, vomiting, and diarrhea to acute respiratory illness, meningitis, ulceration of the intestines, and even death. Coliform bacteria do not have a known effect on aquatic life.

Coliform bacteria from both point and nonpoint sources impact water bodies, although point sources are typically permitted and offer some level of bacteria-reducing treatment prior to discharge. Nonpoint sources of bacteria are diffuse and difficult to characterize. Unfortunately, nonpoint sources often have the greatest impact on bacteria concentrations in water bodies. This is particularly the case in urban storm water and agricultural areas. *E. coli* is often measured in colony forming units (cfu) per 100 ml.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. The excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system.

The first step in identifying a water body’s response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass.

Either phosphorus or nitrogen may be the limiting factor for algal growth, although phosphorous is most commonly the limiting nutrient in Idaho waters. Ecologically speaking, a resource is considered limiting if the addition of that resource increases growth.

Total phosphorus (TP) is the measurement of all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90% of the TP present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than TP that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the TP fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

Nitrogen may be a limiting factor at certain times if there is substantial depletion of nitrogen in sediments due to uptake by rooted macrophyte beds. In systems dominated by blue-green algae, nitrogen is not a limiting nutrient due to the algal ability to fix nitrogen at the water/air interface.

Total nitrogen to TP ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited system. Only biologically available forms of the nutrients are used in the ratios because these are the forms that are used by the immediate aquatic community.

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in the sediments or the water column, aquatic plants will store an abundance of such nutrients in excess of the plants' actual needs, a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays in the water column and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the river sediment. As a result of this process, nutrients (including orthophosphate) that are initially released into the water column in a dissolved form will eventually become incorporated into the river bottom sediment. Once these nutrients are incorporated into the river sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. This cycle is known as nutrient spiraling. Nutrient spiraling results in the availability of nutrients for later plant growth in higher concentrations downstream.

Sediment – Nutrient Relationship

The linkage between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems. Phosphorus is typically bound to particulate matter in aquatic systems and, thus, sediment can be a major source of phosphorus to rooted macrophytes and the water column. While most aquatic plants are able to absorb nutrients over the entire plant surface due to a thin cuticle (Denny 1980), bottom sediments serve as the primary nutrient source for most sub-stratum attached macrophytes. The USDA (1999) determined that other than harvesting and chemical treatment, the best and most efficient method of controlling growth is by reducing surface erosion and sedimentation.

Sediment acts as a nutrient sink under aerobic conditions. However, when conditions become anoxic sediments release phosphorous into the water column. Nitrogen can also be released, but the mechanism by which it happens is different. The exchange of nitrogen between sediment and the water column is for the most part a microbial process controlled by the amount of oxygen in the sediment. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced. This results in a reduction of nitrogen oxides (NO_x) being lost to the atmosphere.

Sediments can play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters and large rivers. In many cases there is an immediate response in phytoplankton biomass when external sources are reduced. In other cases, the response time is slower, often taking years. Nonetheless, the relationship is important and must be addressed in waters where phytoplankton is in excess.

Floating, Suspended, or Submerged Matter (Nuisance Algae)

Algae are an important part of the aquatic food chain. However, when elevated levels of algae impact beneficial uses, the algae are considered a nuisance aquatic growth. The excess growth of phytoplankton, periphyton, and/or macrophytes can adversely affect both aquatic life and recreational water uses. Algal blooms occur where adequate nutrients (nitrogen and/or phosphorus) are available to support growth. In addition to nutrient availability, flow rates, velocities, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. Low velocity conditions allow algal concentrations to increase because physical removal by scouring and abrasion does not readily occur. Increases in temperature and sunlight penetration also result in increased algal growth. When the aforementioned conditions are appropriate and nutrient concentrations exceed the quantities needed to support normal algal growth, excessive blooms may develop.

Commonly, algae blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, blue-green algae often produce toxins that can result in skin irritation to swimmers and illness or even death in organisms ingesting the water. The toxic effect of blue-green algae is worse when an abundance of organisms die and accumulate in a central area.

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water and can produce intense coloration of both the water and shorelines as cells accumulate along the banks. In extreme cases, algal blooms can also result in impairment of agricultural water supplies due to toxicity. Water bodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. The extent of the effect is dependent on both the type(s) of algae present and the size, extent, and timing of the bloom.

When algae die in low flow velocity areas, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, a large algal bloom can substantially deplete DO concentrations near the bottom. Low DO in these areas can lead to decreased fish habitat as fish will not frequent areas with low DO. Both living and dead (decomposing) algae can also affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low DO levels caused by decomposing organic matter can lead to changes in water chemistry and a release of sorbed phosphorus to the water column at the water/sediment interface.

Excess nutrient loading can be a water quality problem due to the direct relationship of high TP concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on DO and pH within aquatic systems. Therefore, the reduction of TP inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae, which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in nutrients (phosphorus), nuisance algae, DO, and pH.

2.4 Summary and Analysis of Existing Water Quality Data

The water quality of the Hangman Creek subbasin in Idaho has been under scrutiny for a number of years. In 1981 the Benewah Soil and Water Conservation District initiated planning and implementation of BMPs to control sediment and nutrient pollution within the watershed (BSWCD, 1981). At that time it was written that,

> *Water quality of Hangman Creek is severely impacted by non-irrigated agriculture. The water quality problems are associated with phosphate, nitrogen, suspended solids, turbidity, bacteria, and toxic chemicals. The uses of Hangman Creek for recreation, drinking water supply, agricultural water supply, and a healthy fishery are impaired. Indications are that the largest single contributor to these problems is cropland runoff."* (BSWCD, 1981)

It should be noted that streambank erosion and to a more limited extent woodland roads were also sources of sediment within the watershed. As a result of the planning efforts much good work was done to organize farmers and to begin to implement voluntary BMPs throughout the watershed.

Flow Characteristics

As seen in Figure 6, flows in Hangman Creek at Tensed, several miles downstream of Sanders, has considerable variation in annual flow with peaks of 1000 cfs or greater and lows below 1 cfs. In the upper part of the watershed above the Tribal boundary, flows can frequently cease during the summer low flow season. All BURP visits into the area recorded flows less than 1cfs (see Table 5) in the early part of July. Such low flows exacerbate water quality problems (temperature, bacteria, and nutrients) and tend to limit habitat for aquatic life.

Table 5. Measured Discharge (cfs) at BURP Sites in upper Hangman Creek Watershed.

Stream	BURP ID	Date Sampled	Measured Discharge
Hangman Creek	2002SCDAA002	7/2/02	0.9 cfs
South Fork Hangman Creek	2002SCDAA003	7/2/02	0.8 cfs
Bunnel Creek	2002SCDAA005	7/8/02	0.4 cfs
South Fork Hangman Creek	2003SCDAA002	7/1/03	0.1 cfs
Martin Creek	2003SCDAA005	7/3/03	0.2 cfs

Water Column Data

Baseline monitoring associated with the BMP planning efforts was conducted in 1981 and 1982 (Bauer and Wilson, 1983). Four sampling stations on the mainstem Hangman Creek and 12 stations on associated tributaries were established and monitored periodically for suspended sediment, phosphorus, nitrogen, bacteria, and other water quality parameters (DO, pH, dissolved solids, total metals).

Suspended sediment sampling specifically targeted two early spring storm events to sample peak runoff. Sediment loads during the larger storm event (February 14-23, 1982) were variable across sampling stations, varying from 0.09 tons/acre at State Park tributary to 2.9 tons/acre in Hangman Creek at DeSmet. Hangman Creek above Sanders station above the South Fork confluence produced 388 tons or 0.35 tons/acre during that same event. The Hangman Creek below Sanders station just above Smith Creek (which would include contributions from Indian Creek) recorded 5,124 tons or 1.44 tons/acre. Sediment yields were much smaller during the second event (March 1-5, 1982) ranging from 0.0005 to 0.2 tons/acre.

Average total phosphorus levels ranged from 0.16 mg/L to 1.32 mg/L for the twelve stations. Average total phosphorus levels above and below Sanders were 0.17 mg/L and 0.16 mg/L, respectively. These TP levels are greater than EPA's 1986 recommendations of 0.1 mg/L TP for flowing streams not entering reservoirs. Average inorganic nitrogen (NO_2+NO_3+NH_3) levels around the watershed varied from 0.23 mg/L to 6.8 mg/L. Inorganic nitrogen averaged 0.23 mg/L and 0.42 mg/L above and below Sanders, respectively.

Fecal coliform levels measured in Hangman Creek above Sanders exceeded water quality standards (200/100ml) 36% of the time. Below Sanders coliform numbers exceed standards 25% of the time. At that time it was determined that bacteria were mostly from human sources and were suspected to be from aging or faulty septic systems.

No DO or metals problems were encountered through this sampling effort. However, pH and hardness were considered naturally very low. Iron was also considerably high by drinking water standards and high levels of suspended sediments were considered the likely source of the iron.

Fortis and Hartz (1991) conducted follow-up monitoring in the watershed at the same 16 stations sampled by Bauer and Wilson (1983). Sampling occurred during 1989-1990, and was intended to provide examination of post-BMP implementation. However, at that time BMPs in the lower part of the watershed had only been in place for a year and were not expected to have achieved their full potential. BMPs in the upper portion of the watershed had been in place for several years prior to re-sampling.

Suspended sediment levels decreased in upper Hangman Creek watershed over the eight year period. Sediment yields were less at DeSmet, Smith Creek, and above and below Sanders than they were eight years before. However, sediment yields in lower parts of the watershed (Lolo Creek, Andrews Springs, State Park, and Clay Pit) showed increases. These data are somewhat limited in scope because they were only taken during several storm events in each study.

Total phosphorus decreased at most stations in the post-implementation study, however inorganic nitrogen increased at most stations. Total phosphorus averaged 0.09 mg/L above Sanders and 0.1 mg/L below Sanders, a 47% and 37% decrease from baseline results, respectively. Phosphorus tends to bind with sediment particles and thus its control is more closely associated with sediment control. Nitrogen on the other hand is more water soluble and tends to be independent of sediment particles.

To our knowledge, no other nutrient sampling has occurred in the upper watershed above Sanders since the Fortis and Hartz (1991) study. Therefore, a quick sampling of total phosphorus was performed in several streams on April 29, 2005. A grab sample was taken from eight sites in six streams (Table 6). The average of all sites was less than 0.04 mg/L.

Table 6. Total phosphorus levels in single grab samples taken on April 29, 2005.

Stream Name	Total Phosphorus (mg/L)
Tenas Creek	0.037
Upper Bunnel Creek	0.032
Lower Bunnel Creek	0.026
Parot Creek	0.054
Hangman Creek	0.037
South Fork Hangman Creek	0.045
South Fork Hangman Creek	0.035
Conrad Creek	0.042
Average	**0.0385**

In order to prevent nuisance algae growth and dissolved oxygen problems, USEPA (1986) developed a national guideline for streams of 0.1 mg/L TP. More recently, USEPA (2000) developed nutrient criteria for total phosphorus of 0.03 mg/L specific to Columbia Plateau sub-ecoregion streams based on the median of all seasons' 25th percentiles. This value roughly corresponds to reference conditions for the Columbia Plateau. These criteria provide USEPA's most recent recommendations to states and authorized tribes for use in establishing their water quality standards. USEPA further recommends that, wherever possible, states develop nutrient criteria that fully reflect localized conditions and protect specific designated uses. The Hangman Creek drainage is an intensely agriculture system, one that is not anticipated to revert to reference quality. Normally, USEPA's earlier guidelines for TP (0.1 mg/L) would be used as a target in Hangman Creek. Current total phosphorus levels in upper Hangman Creek watershed appear to be more similar to reference condition levels. Therefore, it is recommended that no nutrient TMDL be completed for the upper watershed.

NO bacteria, DO, pH, or temperature problems were recorded in the post-implementation study. The highest temperature recorded was 21.5^{o}C at the below Sanders station. These were likely instantaneous temperature recordings taken at the time of other water quality sampling and may not represent maximum daily temperatures. Nor do they account for days when sampling did not occur.

Next, the Soil Conservation Service conducted a preliminary investigation (SCS, 1994) to ascertain conditions in the Hangman Creek watershed and to address continued problems with flooding and erosion in the lower part of the watershed in Idaho. This evaluation rated the condition of the upper portion of the watershed and provided some bank erosion inventory data. The precise location of the inventory is unknown, but was presumably near Sanders. It was concluded that sediment was not a significant problem in the upper watershed and the overall sediment rating was good condition. There were some bank erosion and embeddedness seen that kept the reach examined from achieving an excellent condition rating. Streambank stability was rated at 90% with erosion rates at 0.2 ft/yr on two foot high banks (equivalent to 9.5 tons/mi/yr). No flowing water was seen in the inventory reach at the time of evaluation, only isolated pools with relatively high (23^{o}C) temperatures. It was noted that changes in land use had severely impacted natural hydrology of upper Hangman Creek. The animal waste rating was also good condition and not considered a significant source of pollution. The aquatic habitat condition was fair resulting from over hanging banks and vegetation in poor condition. It was concluded that cold water aquatic life and salmonid spawning could be supported if hydrology could be restored.

The entire watershed in Washington and Idaho was the subject of a restoration project and management plan sponsored by the Spokane County Conservation District (WDOE and SCCD, 1994). That management plan identified the Sanders sub-watershed, an area including Mineral/Smith Creeks and Indian Creek as well as the upper portion of Hangman Creek above the Tribal boundary. This sub-watershed was ranked relatively high (13 of 38) for targeted implementation of best management practices. The ranking system evaluated sediment delivery, evidence of other water quality impairments, the potential for increases in intensity of land use, technical ability to correct problems, the likelihood of success, and the availability of established water quality monitoring sites. The Sanders sub-watershed sediment yield rating was considered moderate with 0.59 acre-feet/sq.mi. (1,157 tons/sq.mi.) annual yield.

The Idaho Department of Lands conducted a cumulative watershed effects (CWE) assessment of the Hangman Creek headwaters area in 2002 (IDL, 2003). The CWE process consists of seven specific assessments including: erosion and mass failure hazards, canopy closure/stream temperature, channel stability, hydrologic risks, sediment delivery, nutrients, and beneficial uses/fine sediment assessment. All but one of these assessments resulted in a low risk rating. Bank stability was the only assessment that received a moderate rating due to some bank sloughing, low bank rock content, bank cutting, lack of large organic debris, channel bottom movement, and channel bottom shape and brightness. The canopy closure rating resulted from aerial photo cover estimates that were predominantly greater than 90% cover.

Temperature

Stream temperature data were collected by the Coeur d'Alene Tribe on Hangman Creek and its tributaries in the region above the Tribal boundary from 2002 to 2004 (see Appendix B). In general, all streams monitored met cold water aquatic life daily maximum criterion (22^{o}C). Hangman Creek at the South Fork Road had one day (July 24, 2004) that exceeded 22^{o}C by a half a degree. Most sites where temperatures were recorded in the spring showed violations of the salmonid spawning daily maximum criterion (13^{o}C). These violations usually occurred in the June 21st to July 15th portion of the default spring spawning season (March 15th to July 15th). Upper Hangman Creek in 2002 had a series of exceedances beginning with a one day excursion on June 15th followed by June 24th through June 28th exceedances, and then July 7th to the end of the spawning period (July 15th). Further downstream and two years later (2004) Hangman Creek at the South Fork Road had several days where temperatures reached 13.5^{o} or 14^{o}C, but then greatly exceeded criteria from June 21st on to July 15th. Stream temperatures at Hangman Forest also exceeded criteria from June 22, 2004 on to the end of the spawning period. Temperature recordings in the South Fork Hangman Creek had some data gaps, however the full season recording at the upper South Fork site showed no violations during 2003. At Martin Creek violations occurred from June 25th on to the end of the spawning period.

<u>Bacteria</u>

Bacteria data were collected in Hangman Creek and the South Fork Hangman Creek in 2002 (Table 7). *Escherichia coli* numbers were high in Hangman Creek during the month of July, but dropped substantially in August. In the South Fork *E. coli* numbers were less consistent with some sampling events high and other low in both months. Most sampling events produced five-day geometric mean values that were in excess of the 126 *E. coli* water quality standard for recreation uses.

Table 7. Bacteria sampling during 2002 for upper Hangman Creek watershed.

Hangman Creek			South Fork Hangman Creek		
Date Sampled	*E. Coli* (cfu/100ml)	5-day Geometric Mean	Date Sampled	*E. Coli* (cfu/100ml)	5-day Geometric Mean
7/8/2002	1100		7/8/2002	730	
7/22/2002	1300		7/22/2002	68	
7/26/2002	730		7/26/2002	64	
7/29/2002	2400		7/29/2002	26	
8/2/2002	99	757	8/2/2002	1000	152
8/5/2002	20	339	8/5/2002	1200	168
8/9/2002	59	193	8/9/2002	21	133
8/13/2002	31	97	8/13/2002	370	189

Biological and Other Data

The following species were captured in 1963 by Coeur d’Alene Tribe personnel in upper Hangman Creek: rainbow trout, eastern brook trout, speckled dace, longnose dace, longnose sucker, northern pikeminnow, chiselmouth, redside shiner, brown bullhead, and tench (WDOE and SCCD, 1994). Water quality work in the 1980s and 1990s reported that catfish, redside shiners, and dace were the primary constituents of the Hangman Creek fishery (SCS, 1994). The creek also supported rainbow trout in the headwaters and in several isolated sections of lower Hangman Creek in the State of Washington at that time. Sculpin have also been observed in the upper watershed by IDFG personnel.

Five BURP sites were sampled in 2002 and 2003 in the upper part of the Hangman Creek watershed above the Tribal boundary (see Appendix C for compilation of BURP data). BURP electrofishing activities resulted in the capture of speckled dace, redside shiner and rainbow trout in Hangman Creek below the South Fork Hangman Creek confluence; sucker, rainbow trout, redside shiner, and speckled dace at the mouth of South Fork Hangman Creek; and rainbow trout in Bunnel Creek.

Status of Beneficial Uses

Beneficial uses in upper Hangman Creek were assessed in 2002 based primarily on temperature data. Although temperature data were available for only Indian Creek at the time, the entire assessment unit (ID17010306PN001_02) which includes South Fork Hangman Creek, Martin Creek, Bunnel Creek and Hangman Creek proper above the South Fork, was identified as being impaired due to temperature. Subsequent temperature data provided by the Coeur d'Alene Tribe for the headwaters streams shows violations of spring salmonid spawning criteria. That same 2002 assessment carried over the original 1998 303d listing for Hangman Creek for the ID17010306PN001_03 assessment unit, which included Hangman Creek downstream from the South Fork confluence. That listing was for sediment, nutrients, and bacteria.

The results of the BURP visits were assessed in 2004 and found to be not supporting aquatic life uses primarily due to low stream fish index (SFI) scores (Table 8). Any average score less than two is considered an indication of non-support.

Table 8. Water body assessment scores for five BURP sites in the upper Hangman Creek watershed.

BURPID	Stream	SMI	SMI Score	SFI	SFI Score	SHI	SHI Score	Ave. Score
2002SCDAA003	SF Hangman Creek	65.4	3	22.3	0	60	3	0
2002SCDAA005	Bunnel Creek	64.5	2	31.2	0	70	3	0
2002SCDAA002	Hangman Creek	49.9	2	8.6	0	61	3	0
2003SCDAA002	SF Hangman Creek	60.1	3	0	0	74	3	0
2003SCDAA005	Martin Creek	54.3	1	n.a.	n.a.	50	1	1

All streams except Martin Creek had good macroinvertebrate (SMI) and habitat (SHI) scores. However, these streams received the lowest scoring for fish diversity (SFI). This seemingly conflicting information may suggest that Hangman Creek headwaters may lack flow necessary to maintain a fishery or that impacts to Hangman Creek downstream are preventing the variety of habitats and migration corridors necessary to maintain a typical fishery in these headwaters. Another possibility is sediment from streambank erosion is affecting spawning habitat and limiting fish production.

Conclusions

Due to a variety of factors, including 303d listings for sediment and bacteria for Hangman Creek below the South Fork confluence, the 303d listing for the assessment unit above the

South Fork for temperature, and bacteria and temperature data from the headwaters area, it was decided that sediment, bacteria, and temperature TMDLs would be completed for all streams in this headwaters area above the Tribal boundary. Total phosphorus levels in the upper watershed had decreased below 0.1mg/L by 1990, the target level used in this watershed to indicate nutrient problems. A more recent, albeit limited sampling of total phosphorus in the upper watershed showed values consistent with ecoregion reference conditions. Thus, no nutrient TMDL will be completed. It is recommended that Hangman Creek above the Coeur d'Alene Tribal boundary be de-listing for nutrients.

2.5 Data Gaps

There has been very little water column data for sediment collected in this portion of the watershed since 1994. And no information is available on depth fines of spawning gravels or on sediment yields from land use activities. Therefore, the sediment TMDL will be based solely on the most recent bank erosion inventory taken in the spring of 2005.

Flow is probably the confounding factor in this headwaters area. Little is known about the available flow throughout the year and what affect it has had on the assessed data. All BURP data collection events in this area had flows less than 1 cfs at the time of sampling (early July). Anecdotal information suggests that the streams in the headwaters area cease to flow for part of the summer, and remain as vernal pools in places until flow returns in the fall. This lack of flow may have a pronounced affect upon the fish community, the reason for the most recent 2004 non-support assessment. Additionally, low flow exacerbates bacteria concentrations and solar loading.

3. Subbasin Assessment–Pollutant Source Inventory

3.1 Sources of Pollutants of Concern

The upper portion of the Hangman Creek watershed above the Coeur d'Alene Tribe Boundary is largely forested with timber harvesting activities being the predominant use of the area. There are several open areas at the lowest part of this area that are used as grazing lands. Additionally, there are less than 20 homes and ranches along the main roads including Sanders Road and Martin Creek Road.

Point Sources

There are no permitted point source discharges in this portion of the watershed. To our knowledge, there are no un-permitted point source discharges either.

Nonpoint Sources

The primary sources of sediment and temperature pollution in the upper Hangman Creek watershed are riparian disturbance and streambank erosion associated with timber harvesting activities, livestock grazing, and development. Bacterial sources are possibly from seepage of pollutants from septic systems, livestock/animal containment and pasturing, and wildlife.

Pollutant Transport

Most of the timber harvesting activities result from private timber companies on private land, presumably practiced in accordance with the state's Forest Practices Act. Forest harvest activities and road construction are the major uses and impacts to the riparian plant communities in the upper watershed (WDOE and SCCD, 1994; IDL, 2003).

Some sediment and thermal pollution appears to be from streambank erosion at the lowest elevations of this segment. Vertical banks and a lack of vegetation are visible on aerial photos for several reaches near the Tribal boundary. It is anticipated that runoff from roads as well as from timber harvest activities increases hydrologic inputs which can accelerate bank erosion, however, the overall contribution from the land appears to be minimal (IDL, 2003).

Septic systems associated with homes in the area and livestock grazing activities are assumed to be the sources of bacteria in this portion of the watershed. Earlier water quality sampling in 1990 suggested that the primary source of bacteria was from human sources based on fecal coliform to fecal streptococcus ratios (Fortis and Hartz, 1991). The 2002 DEQ bacteria sampling (*E. coli*) did not test this hypothesis.

3.2 Data Gaps

Considerable information is needed on bacteria sources and loadings throughout the year.

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4. Subbasin Assessment – Summary of Past and Present Pollution Control Efforts

Considerable effort was put into BMP implementation for the control of non-point source pollution in the Hangman Creek watershed in the 1980s and 1990s (BSWCD, 1981; Bauer and Wilson, 1983; Fortis and Hartz, 1991; SCS, 1994). Benewah County Soil Conservation District received state agricultural water quality program funding to implement BMP contracts on critical areas throughout the watershed in Idaho. Additional funding was provided by the Soil Conservation Service in the form of P.L. 566/Small Watershed Project funding to the conservation district. In upper Hangman Creek 79% of the 6,552 critical acres received $304,861 in contracts for BMPs. Recent CRP contracts have probably increased the number and percentage of contracted acres (WDOE and SCCD, 1994).

Fortis and Hartz (1991) reported that BMP implementation in the upper part of the watershed resulted in decreases in suspended sediment, phosphorus, and bacteria concentrations in less than 10 years. In the lower part of the watershed, pollutant concentrations had not decreased, however, at that time BMPs had been in place only a year and not enough time had passed to show changes (Fortis and Hartz, 1991). These non-point source BMPs have largely been changes in agricultural practices such as conservation tillage, crop rotation, and grass swales.

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5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 In-stream Water Quality Targets

In-stream water quality targets for TMDLs are variable depending on the nature of the pollutant. For bacteria, the in-stream target is the water quality standard for recreation uses.

For sediment and nutrients, no standards are available or practical. Thus we rely upon surrogate targets to achieve a level of pollution reduction necessary to achieve full support of beneficial uses. Stream temperatures are highly complicated and although temperature criteria exist, the use of riparian shade targets is a much more practical approach.

Design Conditions

Sediment

To quantify the seasonal and annual variability and critical timing of sediment loading, climate and hydrology must be considered. This sediment analysis characterizes sediment loads using average annual rates determined from empirical characteristics (i.e. bank erosion, road erosion) that developed over time within the influence of peak and base flow conditions. Annual erosion and sediment delivery are functions of a climate where wet water years typically produce the highest sediment loads. Additionally, the annual average sediment load is not distributed equally throughout the year. Erosion typically occurs during a few critical months. It is difficult to quantify these events, thus a single annual load from each source, the streambanks, roads, and mass failures, is calculated and presumed to represent annual average sediment loading from those sources.

Temperature

There are several important contributors of heat to a stream including ground water temperature, air temperature and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most likely to be controlled or manipulated. The parameters that affect or control the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology affects how closely riparian vegetation grows together and water storage in the alluvial aquifer. The amount of shade provided by objects other than vegetation is not easy to change or manipulate. This leaves vegetation and morphology as the most likely sources of change in solar loading and, hence, temperature in a stream. The relationship between shade and a stream's temperature in the Upper Hangman Creek watershed is briefly examined in Appendix B.

Depending on how much vertical elevation also surrounds the stream, vegetation further away from the riparian corridor can provide shade. However, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure the amount of shade that a stream enjoys in a number of ways. Effective shade, that shade provided by all objects that intercept the sun as it makes its way across the sky, can be measured in a given spot with a solar pathfinder or with optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and the stream's aspect. In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream, and can be measured using a densiometer, or estimated visually either on site or on aerial photography. All of these methods tell us information about how much the stream is covered and how much of it is exposed to direct solar radiation.

Potential natural vegetation (PNV) along a stream is that intact riparian plant community that has grown to its fullest extent and has not been disturbed or reduced in anyway. The PNV can be removed by disturbance either naturally (wildfire, disease/old age, wind-blown, wildlife grazing) or anthropogenically (domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides the most shade and the least achievable solar loading to the stream. Anything less than PNV results in the stream heating up from additional solar inputs. We can estimate PNV from models of plant community structure (shade curves for specific riparian plant communities), and we can measure existing vegetative cover or shade. Comparing the two will tell us how much excess solar load the stream is receiving, and what can be done to decrease solar gain.

Existing shade or cover was estimated for upper Hangman Creek above the Tribal boundary and its tributaries from visual observations of aerial photos. These estimates were field verified by measuring shade with a solar pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at these creeks and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width. Existing and PNV shade was converted to solar load from data collected on flat plate collectors at the nearest National Energy Research Laboratory weather stations collecting these data. In this case, an average of the two nearest stations at Kalispell, MT and Spokane, WA was used. The difference between existing and potential solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are considered to be the lowest achievable temperatures (so long as there are no point sources or any other anthropogenic sources of heat in the watershed).

Pathfinder Methodology

The solar pathfinder is a device that allows one to trace the outline of shade producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the spot that the tracing is made. In order to adequately characterize the effective shade on a reach of stream, ten traces should be taken at systematic or random intervals along the length of the stream in question.

At each sampling location the solar pathfinder should be placed in the middle of the stream about one foot above the water. Follow the manufacturer's instructions (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. Start at a unique location such as 100 m from a bridge or fence line and then proceed upstream or downstream stopping to take additional traces at fixed intervals (e.g. every 100m, every half-mile, every degree change on a GPS, every 0.5 mile change on an odometer, etc.). One can also randomly locate points of measurement by generating random numbers to be used as interval distances.

It is a good idea to take notes while taking solar pathfinder traces, and to photograph the stream at several unique locations. Pay special attention to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade producing ones) are present. Additionally or as a substitution, one can take densiometer readings at the same location as solar pathfinder traces. This provides the potential to develop relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

Canopy coverage estimates or expectations of shade based on plant type and density are provided for 200-foot elevation intervals or natural breaks in vegetation density, marked out on a 1:100K hydrography. Each interval is assigned a single value representing the bottom of a 10% canopy coverage or shade class as described below (*adapted from the CWE process, IDL, 2000)*:

Cover class	Typical vegetation type
0 = 0 – 9% cover	agricultural land, denuded areas
10 = 10 –19%	ag land, meadows, open areas, clearcuts
20 = 20 – 29%	ag land, meadows, open areas, clearcuts
30 = 30 – 39%	ag land, meadows, open areas, clearcuts
40 = 40 – 49%	shrublands/meadows
50 = 50 – 59%	shrublands/meadows, open forests
60 = 60 – 69%	shrublands/meadows, open forests
70 = 70 – 79%	forested
80 = 80 – 89%	forested
90 = 90 –100%	forested

The visual estimates of shade in this TMDL were field verified with a solar pathfinder. The pathfinder measures effective shade and is taking into consideration other physical features that block the sun from hitting the stream surface (e.g. hillsides, canyon walls, terraces, man-made structures). The estimate of shade made visually from an aerial photo does not take into account topography or any shading that may occur from physical features other than vegetation. However, research has shown that shade and cover measurements are remarkably similar (OWEB, 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade.

Stream Morphology

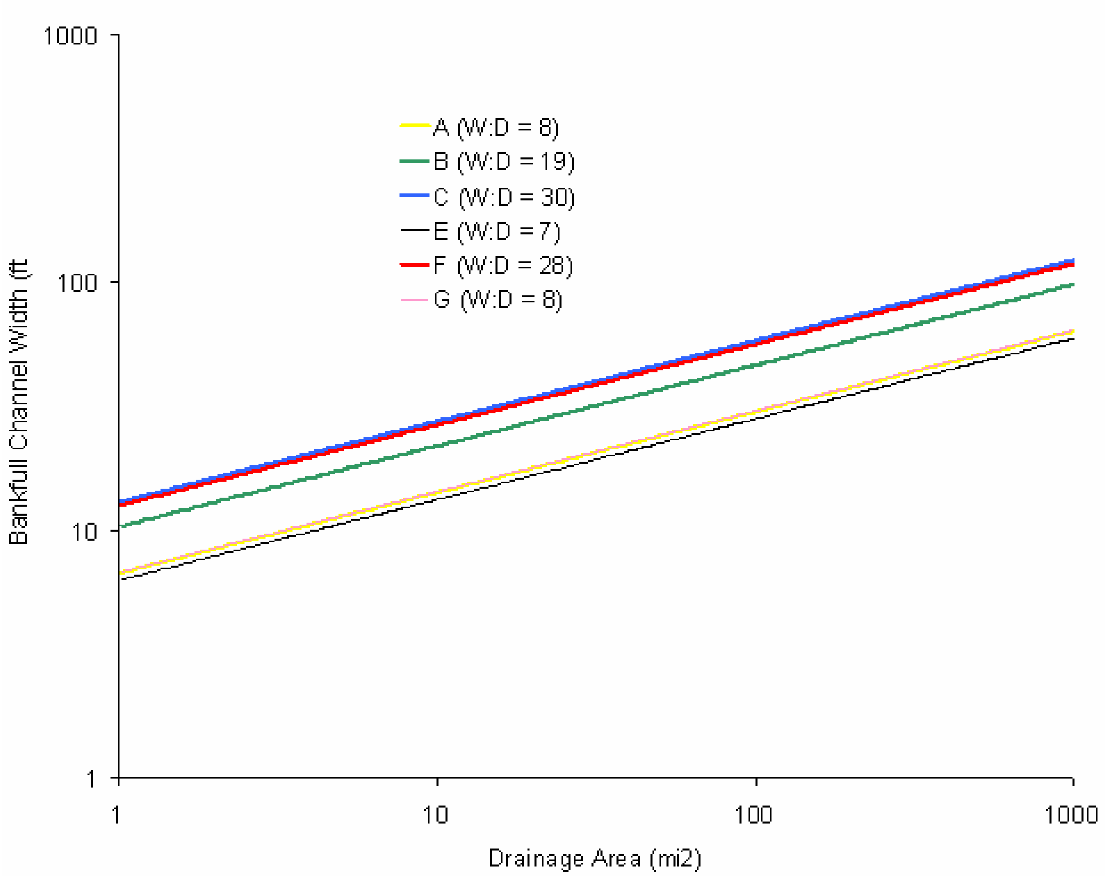
Measures of current bankfull width or near stream disturbance zone width may not reflect widths that were present under PNV. As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallow. Wider streams mean less vegetative cover to provide shading.

Shade target selection, which involves evaluating the amount of shade provided at PNV conditions, necessitates recognition of potential natural stream widths as well. In this TMDL appropriate stream widths for shade target selection were determined from analysis of existing stream widths and the relationship between drainage area and width-to-depth ratios

(Rosgen, 1996). Figure 11 (from IDEQ, 2002) shows the relationship between drainage area and bankfull width for the various level 1 Rosgen channel types.

The streams in the upper Hangman Creek watershed are small given that only the very tip of the Hangman Creek watershed area is involved. A sliding scale of stream widths was developed for the various streams in question with the lower ends of Hangman Creek and South Fork Hangman Creek receiving a 3m wide channel (drainage areas for both are approximately 8-10 mi^2) and decreasing upstream to headwaters areas with 0.5m wide channels. Thus, small headwater streams such as Hill Creek and Bunnel Creek will have natural stream widths of 0.5m. Larger headwater streams such as Martin Creek and Conrad Creek will increase from 0.5m in their headwaters to 1m wide at their mouths. Finally, the largest streams (Hangman Creek and South Fork Hangman Creek) run the gamete from 0.5m in their headwaters, then 1m, 2m, and 3m at their lowest point in this section of the watershed.

Figure 11. Bankfull Width as a Function of Width to Depth Ratio and Drainage Area.



<u>Bacteria</u>

In the case of bacteria and recreation uses, the warmer months of the year including late spring, summer and early fall are considered the critical time period to protect recreational users of surface waters from bacterial contamination. In this TMDL, bacteria data were collected during summer months so little is known about bacterial contamination in spring following runoff or in the fall. Bacterial contamination is also highly affected by flow. Thus, in this TMDL, bacteria loads are developed based on flow. Subsequent monitoring to implement this bacteria TMDL will require measurement of flow at the same time as bacteria concentration.

In this TMDL, *E. coli* data collected in July and August of 2002 did not have concomitant flow data. However, flow was measured at the bacteria sample locations several days prior to sampling during the BURP crew visits. Flow measured by the BURP crew was 0.9 cfs in Hangman Creek and 0.8 cfs in SF Hangman Creek on July 2, 2002. Bacteria sampling commenced on July 8, 2002 and continued approximately every week until August 13, 2002. In order to estimate flow during the bacteria sampling events, flow data from the Tekoa gage provided by the Coeur d'Alene Tribe was used to estimate flow at the bacteria sampling locations. Table 9 shows the mean daily flow at the Tekoa gage, the change in flow from one sample date to the next (as a fraction of the difference), and the flow estimates for Hangman Creek and SF Hangman Creek based on that change. Negative change, although counterintuitive, results from an increase in flow during the latter date.

Flow at the Tekoa gage decreased from 3.25 cfs on July 2nd to 0.72 cfs on August 2nd with rates of change varying from 29%, 48%, 6%, 13%, and 26% over the range of sample dates. For the remaining three sample dates in August flow increased at the Tekoa gage to 0.9 cfs on August 13th with flow increases ranging from 5% to 11%. These rates of change were applied to the flow measured at the Hangman Creek and SF Hangman Creek BURP sites on July 2, 2002. Thus, Hangman Creek's flow decreased from 0.9 cfs to 0.2 cfs, then increased to 0.24 cfs during the course of bacteria sampling. The South Fork's flow decreased from 0.8 cfs to 0.18 cfs, then increased to 0.22 cfs.

Table 9. Mean daily flow measured at the Tekoa gage and estimated for Hangman Creek and its South Fork.

Mean Daily Flow (cfs)				
Sample Date	Tekoa Gage	Date to Date Change in Flow (as a fraction)	Hangman Creek Estimate	SF Hangman Creek Estimate
7/2/2002	3.25		0.90[a]	0.80[a]
7/8/2002	2.31	0.2892	0.64	0.57
7/22/2002	1.19	0.4848	0.33	0.29
7/26/2002	1.12	0.0588	0.31	0.28
7/29/2002	0.976	0.1286	0.27	0.24
8/2/2002	0.724	0.2582	0.20	0.18
8/5/2002	0.802	-0.1077	0.22	0.20
8/9/2002	0.841	-0.0486	0.23	0.21
8/13/2002	0.88	-0.0464	0.24	0.22

a = These are measured flows during BURP visit.

Target Selection

Sediment

Sediment targets for this TMDL are based on streambank erosion, road erosion, and mass failure quantitative allocations in tons/year. The reduction in streambank erosion prescribed in this TMDL is directly linked to the improvement of riparian vegetation density to armor streambanks thereby reducing lateral recession, trapping sediment and reducing stream energy, which in turn reduces stream erosivity and instream sediment loading. It is assumed that by reducing chronic sediment, there will be a decrease in subsurface fine sediment that will ultimately improve the status of beneficial uses.

It is assumed that natural background sediment loading rates from bank erosion equate to 80% bank stability as described in Overton and others (1995), where banks are expressed as a percentage of the total estimated bank length. Natural condition streambank stability potential is generally 80% or greater for Rosgen A, B, and C channel types in plutonic, volcanic, metamorphic, and sedimentary geology types. Therefore, an 80% bank stability target based on streambank erosion inventories shall be the target for sediment.

Road erosion and mass failure estimates of sediment delivery were determined from the CWE assessment of the upper Hangman Creek area (IDL, 2003). Sediment delivery from road erosion was determined from the CWE score for forest roads and the relationship between these scores and sediment export developed by McGreer (1998). The volume estimate and percent delivery from mass failures, provided by the CWE assessment (IDL, 2003) was converted directly to tons of sediment using a bulk density of 100 lbs/ft^3. Target values for road erosion and mass failure are based on the concept of 50% above background is threshold. It is assumed here that background is zero for these sources, which may be accurate for roads, but incorporates a margin of safety for mass failures as no natural mass failures are assumed. Therefore, a target based on 50% reduction in these events was used for this TMDL.

Temperature

A single effective shade target was developed for all streams in this portion of the watershed. Because stream widths are small, no greater than 3m, just about any tree or large shrub community, deciduous or conifer is going to provide the maximum amount of shade. Shade curves developed for other TMDLs in the Northwest (South Fork Clearwater, Idaho; Walla Walla River, Oregon; Willamette River, Oregon; Mattole River, N. California) all show that maximum shading occurs at stream widths less than three meters. Because existing shade was evaluated on 10% intervals with the lowest value representing that interval (i.e. 90% represents the shade class of 90% to 100%), the target is also based on this value. Hence the effective shade target for all streams in this TMDL is 90%. This is a higher target than was developed by IDL through its CWE process by about 10% (IDL, 2003).

Bacteria

Bacteria targets are the water quality standard for recreation uses or 126 cfu/100ml of *E. coli*. For any given flow, the number of colonies the water body can contain and still meet this target is derived from multiplying the flow (converted to milliliters) by 1.26cfu.

Monitoring Points

Sediment

Sediment loadings are based on streambank erosion inventories conducted on representative reaches, road erosion and mass failures. Future implementation monitoring should include continued use of erosion inventories on representative reaches in the watershed and the CWE assessment of roads and mass failures. Each reach evaluated in the streambank inventory for this TMDL represents similar types of reaches in the watershed. It is not necessary to sample these exact locations again. Other reaches for each type represented should be evaluated too to take into account variation in the type.

Temperature

Solar loadings in this TMDL are based on aerial photo interpretation of 1:100K hydrography streams in the entire watershed under investigation. These interpretations are field verified at specific locations. Future monitoring should include continued use of aerial photo interpretation of future photos with field verification. Solar pathfinder field verification does not need to take place in exact locations where current field verifications were taken.

Bacteria

Increased monitoring of bacteria is needed to ascertain the source(s) and extent of bacterial contamination in the watershed. Currently it is not known whether the bacteria are from animal or human sources. Future monitoring should include more site specific monitoring, more times of the year, and DNA analysis of animal source.

5.2 Load Capacity

Loading capacities for pollutants in these TMDLs are based on achieving specific targets. For sediment and bacteria in most cases a 10% margin of safety is taken "off the top" by removing 10% of the loading capacity from consideration. Temperature loading capacities or solar loading capacities are based on potential natural vegetation levels blocking solar radiation. As such, an implicit margin of safety is included in the loading capacity because no less solar loading can be achieved.

Sediment

Bank stability of 80% produces an erosion rate based on the recession rate and stream size evaluated in each streambank erosion inventory (see Appendix D). Thus, each inventoried reach and the length of stream that the inventory represents has a proposed erosion rate (tons/mi/yr) and a proposed total erosion (tons/yr) (see Table 10a). These values as seen on each inventory worksheet and Table 10a represent the loading capacity of the stream. Loading capacities vary from less than 5 tons/mi/yr on small forested streams (Bunnel Creek, Hill Creek, and upper Conrad Creek) to 19 tons/mi/yr on larger forested segments (upper South Fork Hangman Creek, middle Hangman Creek, lower Conrad Creek, and middle to upper Martin Creek) to greater than 50 tons/mi/yr on lower segments of Hangman Creek, South Fork Hangman Creek, and Martin Creek.

The loading capacity of the streams for road erosion and mass failures is based on a 50% above background threshold value (Washington Forest Practices Board, 1995). In this TMDL it is assumed that zero loading from these sources is background. Therefore a reduction of 50% is imposed in this TMDL to help mitigate the effects of human disturbance in the watershed.

Temperature

The loading capacity for stream temperature is based on the solar loading to a stream with 90% effective shade. We use the summer average solar loading (average of six months from April through September) as a benchmark. One hundred percent solar loading to a flat plate collector with zero tilt as measured at the National Renewable Energy Laboratory Spokane station averages 5.7 kWh/m^2/day for this summer period. If 90% of that loading is blocked by effective shade, then only 10% of that loading or 0.57 kWh/m^2/day reaches the stream at target conditions. The loading capacity of 0.57 kWh/m^2/day is listed in Tables 11 through 16 as Potential Summer Load.

Bacteria

The bacteria loading capacity is based on flow (Table 9) and the *E. coli* water quality standard of 126cfu/100ml. Flow (cfs) was converted to milliliters and then multiplied by 1.26. Figures 12 and 13 show the relationship between flows and the number of *E.coli* colonies the stream can contain and still meet the water quality standard. A flow of 1cfs can contain 35,679 cfu of *E. coli* at loading capacity. Figures 12 and 13 also show existing bacteria loads in Hangman Creek and SF Hangman Creek based on 5-day geomeans.

Figure 12. Loadings of E. Coli bacteria in Hangman Creek based on flow. The loading capacity does not reflect any reductions from a margin of safety.

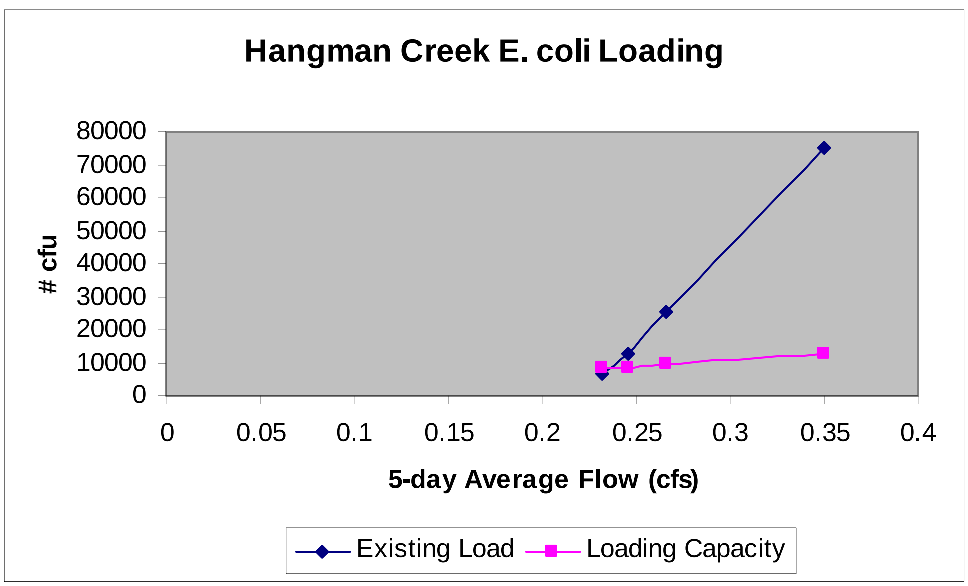
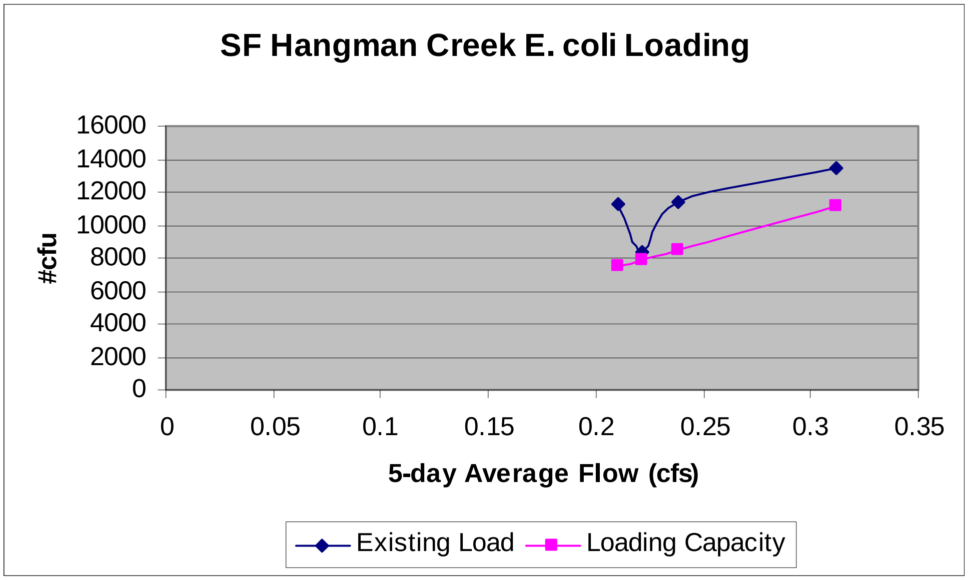


Figure 13. Loadings of E. Coli bacteria in SF Hangman Creek based on flow. The loading capacity does not reflect any reductions from a margin of safety.



5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR § 130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (land use) and area (such as a subwatershed), but may be aggregated by type of source or land area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

Sediment

Forest road sediment yield was estimated using the relationship between the CWE road score and sediment yield per mile of road developed by McGreer (1998) for the LeClerc Creek watershed. The CWE road score of 17.2 produced by the CWE assessment of the upper Hangman Creek watershed (IDL, 2003) resulted in a sediment yield of 3.8 tons/mile/year. The CWE assessment (IDL, 2003) indicated that there were 71 miles of forest road in the portion of the watershed analyzed. This results in a sediment yield from roads of 270 tons/year (Table 10b).

Three mass failures were evaluated in the upper watershed by the CWE assessment (IDL, 2003). Their volume estimates were 20, 10 and 10 cubic yards (yds^3) with percent delivery ratings of 20%, 5%, and 5%, respectively. The combination results in a total of 5 yds^3 delivered to the streams from mass failure. Using an average bulk density of 100 lbs/ft^3, that 5 yds^3 weighs slightly less than 7 tons (Table 10b).

Existing streambank erosion rates were measured at eight reaches in the upper Hangman Creek watershed (see Figure 14). These eight reaches were used to represent larger portions of the upper watershed under evaluation. For example, Reach 1 was a 239m (785ft) stretch of middle Martin Creek that was used to represent 2,000m of middle to upper Martin Creek and 2,700m of middle to lower Conrad Creek; an area of mixed forest and shrub that was deemed similar due elevation, stream size and history of land use. Reach 2 represents 600m of lower Martin Creek. Reach 3 represents intact forest on 950m of Bunnel Creek, 1,500m of upper Hangman Creek, 1,700m of Hill Creek and 1,100m of upper Conrad Creek. Reach 4 represents gallery forest along roads from 2,700m of the South Fork Hangman Creek and 2,000m of middle Hangman Creek. Reach 5 was measured approximately three miles downstream of the Tribal boundary outside of the upper watershed area under investigation. Reach 5 was used to represent brushy areas at the widest portion of the upper watershed; 960m of lower Hangman Creek and 230m of lower South Fork Hangman Creek. Reach 6 was measured on lower Tenas Creek, a small tributary to Martin Creek. This reach was sampled in a freshly harvested forest area to provide some idea of erosion from such activities. Reach 6 represents 950m of Tenas Creek. Reach 7 was also sampled in a recently harvested area on upper Bunnel Creek. This reach represents 1,200m of upper Bunnel Creek. Finally, Reach 8 was sampled in a brushy area along lower South Fork Hangman Creek, and was used to represent 2,010m of that creek.

Table 10a. Sediment Loading Analysis for Upper Hangman Creek Watershed. The Proposed Total Erosion includes the removal of 10% as a margin of safety.

Reach Number	Segment Measured	Segments Represented	Existing		Proposed		Percent (%) Reduction
			Erosion Rate (t/mi/yr)	Total Erosion (tons/yr)	Erosion Rate (t/mi/yr)	Total Erosion – 10% MOS (tons/yr)	
1	Upper Martin Creek	Middle to upper Martin, Middle to lower Conrad	22.4	37.5	19.4	29.3	22
2	Lower Martin Creek	Lower Martin Creek	95.9	35.8	52	17.5	51
3	Lower Bunnel Creek	Lower Bunnel, Hill Creek, upper Conrad, upper Hangman	1.7	5.5	4.7	13.8	0
4	Upper SF Hangman Creek	Upper SF Hangman, middle Hangman	19.1	55.7	19.3	50.8	9
5	Hangman Creek	Lowest portion of Hangman and SF Hangman	730.2	435.7	196	116.9*	73
6	Tenas Creek	Lower Tenas Creek	15	8.9	12.8	6.8	23
7	Upper Bunnel Creek	Upper Bunnel Creek	2.3	1.7	4.2	2.8	0
8	Lower SF Hangman Creek	Lower SF Hangman Creek	137.6	171.8	90.3	101.5	41
Total	Watershed	Above Tribal Boundary		752.6		339.4	55

*No margin of safety has been subtracted from Reach 5 due to over estimation (see text).

Existing erosion rates vary from approximately 2 tons/mile/year in the forested areas of Bunnel Creek, Hill Creek, and upper Conrad and Hangman Creeks to 730 tons/mile/year on lowest portions Hangman and South Fork Hangman Creeks (Table 10a). Middle to upper Martin Creek and middle to lower Conrad Creek erosion rates were near 22 tons/mile/year. Likewise, upper South Fork Hangman Creek and middle Hangman Creek had erosion rates of 19 tons/mile/year. Whereas the lower portions of the South Fork and Martin Creek had rates around 95 to 137 tons/mile/year. The heavily harvested area of Tenas Creek had an erosion rate of 15 tons/mile/year compared to the 2 tons/mile/year on the slightly older harvested area on upper Bunnel Creek.

Table 10b. Sediment Allocations by Source.

Source	Existing Load (t/yr)	Loading Capacity (t/yr)	Reduction (%)
Streambanks	753	339	55
Roads	270	135	50
Mass Failure	7	3.5	50
Total	1030	477.5	54

In terms of total annual erosion, the entire watershed above the Tribal boundary released more than twice as much sediment as it should (Table 10b). Reductions in road and mass failure sediment delivery were pre-determined at 50% (Washington Forest Practices Board, 1995). For streambanks, reduction for the whole watershed above the Tribal boundary is about 55%. Martin Creek and most of Conrad Creek together released about 73 tons from their banks compared to the 7 tons/year released from the forested areas around much smaller Bunnel Creek, Hill Creek, upper Conrad Creek, and the very tip of Hangman Creek (Table 10a). Upper South Fork Hangman Creek and middle Hangman Creek together released about 56 tons/year, whereas the lower portion of South Fork Hangman Creek released 172 tons/year alone. The lowest 0.6 miles of Hangman Creek and South Fork Hangman Creek released the greatest amount of sediment at 436 tons/year, however, that is based on data collected at Reach 5 several miles below these reaches. It is likely that actual releases from this area are less due to less stream volume and slightly better riparian vegetation/bank conditions. This provides a built in margin of safety for Reach 5, thus no 10% MOS was subtracted from its loading capacity.

Upper Bunnel Creek and Tenas Creek provide data on likely erosion from forest harvest activities on these smaller headwater streams. Erosion from upper Bunnel Creek is less than that from Tenas Creek, which may reflect slight differences in time since harvest within upper Bunnel Creek having more time to recover.

Temperature

All streams in this portion of the Hangman Creek watershed that exist on a 1:100K hydrography were assigned existing shade values at natural break intervals (see Figure 14). Existing shade values ranged from 40% to 90%.

Existing summer solar loads were calculated by multiplying the flat plat collector solar load value (5.7 kWh/m^2/day) by one minus the existing shade value (as a fraction) for a particular reach of stream. Thus, if existing shade is 70%, then the existing load is calculated as 1 - 0.7 = 0.3 x 5.7 kWh/m^2/day = 1.71 kWh/m^2/day.

Tables 11 through 16 show existing shade values and their corresponding existing summer solar load for all streams evaluated. Because solar load is provided on an area basis, total stream loads (in kWh/day) were calculated by first deriving the stream reach area (m^2) from the length times stream width, and then multiplying that area times the existing summer load in kWh/m^2/day.

Bacteria

E. coli was sampled eight times over a two month period from July 8, 2002 to August 13, 2002 at two locations (Hangman Creek and South Fork Hangman Creek). To our knowledge no flow measurement were taken at the time of sampling for bacteria. Therefore, in order to produce existing loads the most recent flow measurements taken during BURP monitoring visits (July 2, 2002) were used to estimate flows during bacteria sampling. At that time flow was measured at 0.9cfs and 0.8cfs in Hangman Creek and South Fork Hangman Creek, respectively. Flow was measured during the sampling dates at the Tekoa gage, which was used to produce the relative difference in flow during subsequent bacteria sampling dates. Loadings based on the first through the forth running geometric mean calculated from the eight samples (Table 7) were produced at these flows and displayed in Table 10c and Figures 12 and 13 (see Appendix F for loading analysis).

Table 10c. Numbers of *E. coli* colonies in stream at loading capacity (minus 10% MOS) and at the four geomeans, and the percent (%) reduction necessary to achieve the loading capacity.

Stream	Flow (cfs)	Load Capacity	Geo-means	% Reduction
Hangman Creek	0.35	11,203	74,992	85
	0.266	8,542	25,571	67
	0.246	7,899	12,741	38
	0.232	7,450	6,388	0
SF Hangman Creek	0.312	10,019	13,477	26
	0.238	7,643	11,355	33
	0.222	7,129	8,374	15
	0.21	6,744	11,251	40

Figure 14. Existing shade values for various reaches in the upper Hangman Creek watershed

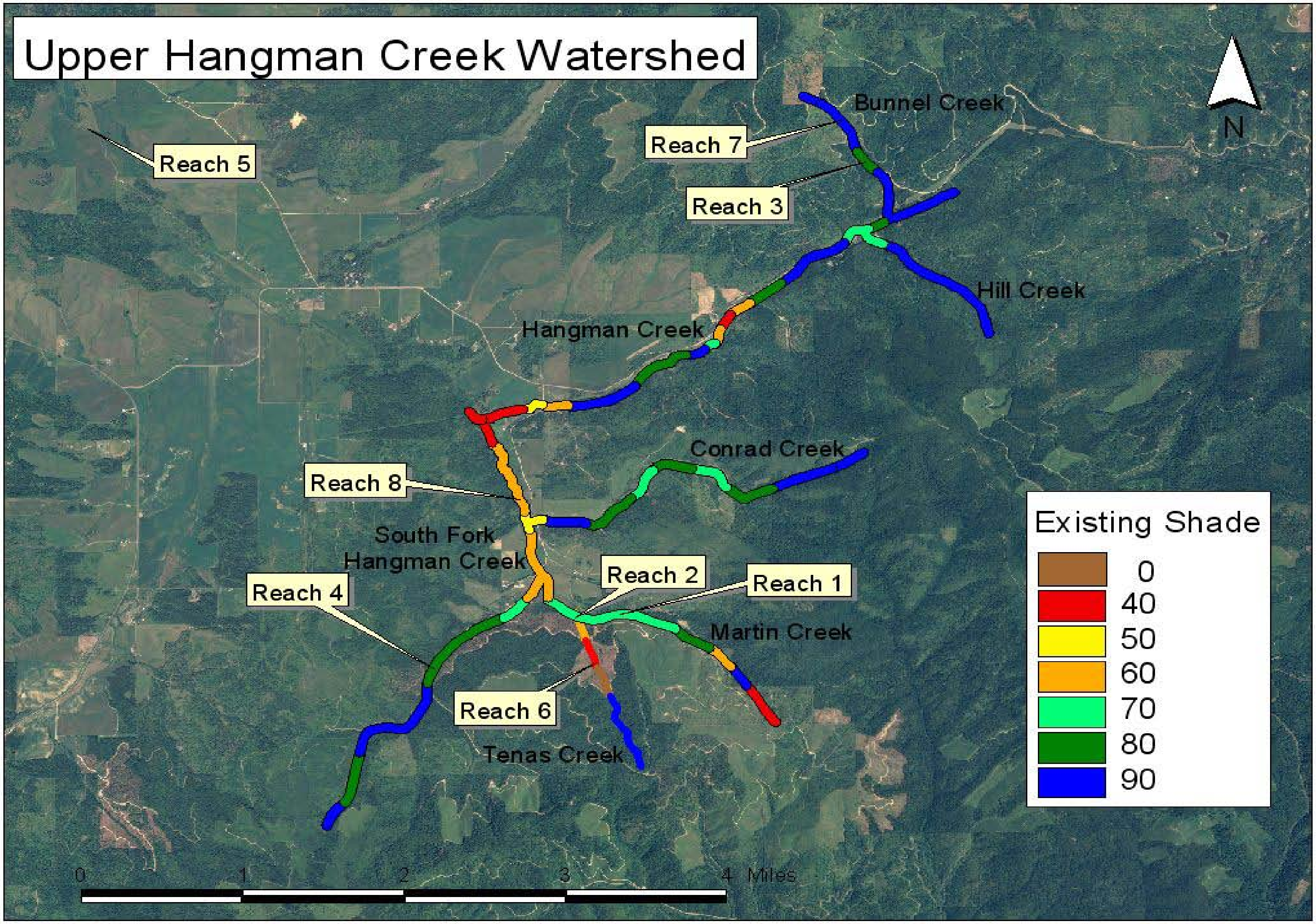


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Table 11. Solar loading analysis for Hangman Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)
0.5 (headwtr)	0.9	0.57	0.9	0.57	0.00
0.2	0.8	1.14	0.9	0.57	-0.57
0.2	0.7	1.71	0.9	0.57	-1.14
0.6	0.9	0.57	0.9	0.57	0.00
0.3	0.8	1.14	0.9	0.57	-0.57
0.2	0.6	2.28	0.9	0.57	-1.71
0.1	0.4	3.42	0.9	0.57	-2.85
0.1	0.6	2.28	0.9	0.57	-1.71
0.15	0.7	1.71	0.9	0.57	-1.14
0.1	0.9	0.57	0.9	0.57	0.00
0.3	0.8	1.14	0.9	0.57	-0.57
0.4	0.9	0.57	0.9	0.57	0.00
0.2	0.6	2.28	0.9	0.57	-1.71
0.15	0.5	2.85	0.9	0.57	-2.28
0.3 (boundary)	0.4	3.42	0.9	0.57	-2.85
Average	**0.7**	**1.7**	**0.9**	**0.6**	**-1.1**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
805	402.5	229.43	0.5	229.43	0
322	322	367.08	1	183.54	-183.54
322	322	550.62	1	183.54	-367.08
966	1932	1101.24	2	1101.24	0
483	966	1101.24	2	550.62	-550.62
322	644	1468.32	2	367.08	-1101.24
161	322	1101.24	2	183.54	-917.7
161	322	734.16	2	183.54	-550.62
241	723	1236.33	3	412.11	-824.22
161	483	275.31	3	275.31	0
483	1449	1651.86	3	825.93	-825.93
644	1932	1101.24	3	1101.24	0
322	966	2202.48	3	550.62	-1651.86
241	723	2060.55	3	412.11	-1648.44
483	1449	4955.58	3	825.93	-4129.65
Total	**12957.5**	**20136.7**		**7385.8**	**-12750.9**

Table 12. Solar loading analysis for South Fork Hangman Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)
0.5(headwtr)	0.9	0.57	0.9	0.57	0.00
0.3	0.8	1.14	0.9	0.57	-0.57
0.7	0.9	0.57	0.9	0.57	0.00
0.7	0.8[a]	1.14	0.9	0.57	-0.57
0.3	0.7	1.71	0.9	0.57	-1.14
0.5	0.6	2.28	0.9	0.57	-1.71
0.1	0.5	2.85	0.9	0.57	-2.28
0.5	0.6[b]	2.28	0.9	0.57	-1.71
0.2(mouth)	0.4	3.42	0.9	0.57	-2.85
Average	**0.7**	**1.8**	**0.9**	**0.6**	**-1.2**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
805	402.5	229.43	0.5	229.43	0.00
483	241.5	275.31	0.5	137.66	-137.66
1127	1127	642.39	1	642.39	0.00
1127	1127	1284.78	1	642.39	-642.39
483	483	825.93	1	275.31	-550.62
805	1610	3670.80	2	917.70	-2753.10
161	322	917.70	2	183.54	-734.16
805	2415	5506.20	3	1376.55	-4129.65
322	966	3303.72	3	550.62	-2753.10
Total	**8694**	**16656.3**		**4955.6**	**-11700.7**

[a] solar pathfinder measurements = 88.8%; [b] solar pathfinder measurements = 61.6%

Table 13. Solar loading analysis for Hill Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)
1	0.9	0.57	0.9	0.57	0.00
0.2	0.7	1.71	0.9	0.57	-1.14
Average	**0.8**	**1.1**	**0.9**	**0.6**	**-0.6**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
1609	804.5	458.57	0.5	458.57	0.00
322	161	275.31	0.5	91.77	-183.54
Total	**965.5**	**733.9**		**550.3**	**-183.5**

Table 14. Solar loading analysis for Conrad Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)
0.7(headwtr)	0.9	0.57	0.9	0.57	0.00
0.3	0.8	1.14	0.9	0.57	-0.57
0.3	0.7	1.71	0.9	0.57	-1.14
0.2	0.8	1.14	0.9	0.57	-0.57
0.2	0.7	1.71	0.9	0.57	-1.14
0.4	0.8	1.14	0.9	0.57	-0.57
0.3	0.9	0.57	0.9	0.57	0.00
0.1	0.5	2.85	0.9	0.57	-2.28
Average	**0.8**	**1.4**	**0.9**	**0.6**	**-0.8**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
1127	563.5	321.20	0.5	321.20	0.00
483	241.5	275.31	0.5	137.66	-137.66
483	483	825.93	1	275.31	-550.62
322	322	367.08	1	183.54	-183.54
322	322	550.62	1	183.54	-367.08
644	644	734.16	1	367.08	-367.08
483	483	275.31	1	275.31	0.00
161	161	458.85	1	91.77	-367.08
Total	**3220**	**3808.5**		**1835.4**	**-1973.1**

Table 15. Solar loading analysis for Bunnel Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)
0.6	0.9[a]	0.57	0.9	0.57	0.00
0.2	0.8[b]	1.14	0.9	0.57	-0.57
0.3	0.9	0.57	0.9	0.57	0.00
Average	**0.9**	**0.8**	**0.9**	**0.6**	**-0.2**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
966	483	275.31	0.5	275.31	0.00
322	161	183.54	0.5	91.77	-91.77
483	241.5	137.66	0.5	137.66	0.00
Total	**885.5**	**596.5**		**504.7**	**-91.8**

[a] solar pathfinder measurements = 90.1%; [b] solar pathfinder measurements = 88.5%

Table 16. Solar loading analysis for Martin Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)
0.2(headwtr)	0.4	3.42	0.9	0.57	-2.85
0.2	0.9	0.57	0.9	0.57	0.00
0.2	0.6	2.28	0.9	0.57	-1.71
0.15	0.8	1.14	0.9	0.57	-0.57
0.8	0.7[a]	1.71	0.9	0.57	-1.14
0.2(mouth)	0.6	2.28	0.9	0.57	-1.71
Average	**0.7**	**1.9**	**0.9**	**0.6**	**-1.3**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
322	161	550.62	0.5	91.77	-458.85
322	161	91.77	0.5	91.77	0.00
322	161	367.08	0.5	91.77	-275.31
241	120.5	137.37	0.5	68.69	-68.69
1287	1287	2200.77	1	733.59	-1467.18
322	322	734.16	1	183.54	-550.62
Total	**2212.5**	**4081.8**		**1261.1**	**-2820.6**

[a] solar pathfinder measurements = 72.3%

Table 17. Solar loading analysis for Tenas Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)
0.6(headwtr)	0.9	0.57	0.9	0.57	0.00
0.2	0	5.7	0.9	0.57	-5.13
0.2	0.4[a]	3.42	0.9	0.57	-2.85
0.2(mouth)	0.6	2.28	0.9	0.57	-1.71
Average	**0.5**	**3.0**	**0.9**	**0.6**	**-2.4**

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
966	483	275.31	0.5	275.31	0.00
322	161	917.70	0.5	91.77	-825.93
322	161	550.62	0.5	91.77	-458.85
322	161	367.08	0.5	91.77	-275.31
Total	**966**	**2110.7**		**550.6**	**-1560.1**

[a] solar pathfinder measurements = 43.9%

5.4 Load Allocation

There are no known or anticipated point sources of pollutants in this portion of the watershed. Therefore all load allocations are for nonpoint sources and there are no wasteload allocations. No attempt was made to differentiate between different activities or sources. Therefore, the entire available loads are allocated as a whole to the nonpoint source activities and background conditions that may create the pollutant.

<u>Sediment</u>

The loading capacity in Table 10b is assumed to be the available loading capacity or the streambank loading capacity minus a 10% margin of safety, and represents the available sediment load to be allocated. Because loading capacities for roads and mass failures were not determined, a threshold reduction of 50% was applied (Washington Forest Practices Board, 1995). Intensive row crop farming does not occur in this portion of the watershed. It is assumed that negligible amounts of sediment are entering the streams as runoff from the small amount of pasture land, and that the majority of sediment loading comes from streambanks, roads and mass failures as the result of bank perturbations or increased hydrology or runoff volumes from land use activities. Therefore, the available loading capacity is allocated to these three nonpoint sources. It is implied that all nonpoint source activities should not increase bank erosion greater than the 80% bank stability target, and that forest land use activities should reduce road and mass failure sediment delivery by 50%.

All stream except Bunnel Creek require a reduction in existing streambank sediment loading to achieve loading capacity (minus 10% MOS) (Table 10a). Reach 4 representing upper

South Fork Hangman Creek and middle Hangman Creek had an existing erosion rate (19.1 t/mi/yr) slightly less than its proposed erosion rate (19.3 t/mi/yr), however, due to the removal of 10% of the proposed total for a MOS, existing total erosion was slightly greater than proposed total erosion resulting in the need for 9% reduction. Lower Hangman Creek, lower South Fork Hangman Creek and lower Martin Creek require the largest reduction in sediment loading to meet targets. The watershed as a whole above the Tribal boundary requires a 54% reduction in sediment loading to meet loading capacity (Table 10b).

Temperature

All streams require some reduction in solar loading to achieve loading capacity. In Tables 11 through 16 existing summer load was subtracted from potential summer load to reflect the amount of load reduction necessary to achieve potential or target loads. Bunnel Creek and Hill Creek require the least with 15% and 25% reduction, respectively. Percent reductions in summer load to achieve potential load for the remaining streams are 52% for Conrad Creek, 63% for Hangman Creek, 69% for Martin Creek, 70% for South Fork Hangman Creek, and 74% for Tenas Creek.

The loading analysis is based on effective shade provided by riparian vegetation. The load allocation is to nonpoint source activities and background conditions that may have an effect on riparian vegetation and its shading potential. It is implied that nonpoint source activities should not reduce effective shade below potential natural vegetation target levels.

Because potential summer loads are based on the concept of achieving shade levels under potential natural vegetation, an inherent margin of safety is implied as no better shade conditions are considered achievable.

Bacteria

Because sources are not often continuous in their discharge and bacteria are not long-lived, bacteria concentrations vary considerably from one time period to the next. This is reflected in the changing geometric mean throughout the sampling period in hangman Creek and South Fork Hangman Creek (Table 7). Percent reductions in bacteria numbers necessary to achieve loading capacities (minus a 10% MOS) vary for each geometric mean calculated (Table 10c). In Hangman Creek, necessary reductions steadily decline through the sampling period from an 85% reduction for the first geometric mean down to 0% reductions for the fourth geometric mean. In the South Fork, this relationship does not exist with the fourth geometric mean showing the highest necessary reduction (40%) and the other geo-means variable (26%, 33%, and 15% reductions necessary for the first through the third geo-means, respectively).

The sources of the bacterial contamination are not known. To our knowledge there are no confined animal feeding operations of any size in the upper watershed. However, there may be a few barnyard or pastured animals with direct access to the creeks. Bauer and Wilson (1983) suspected that bacterial contamination in the Hangman Creek watershed was from human sources, most likely aging or malfunctioning septic systems resulting in discharge to the creeks. However, there are not many homes in this portion of the watershed and the problem is not likely due to a concentration of malfunctioning systems.

Substantial additional work needs to be done to isolate the source or sources of bacterial contamination in these creeks. That work includes more site specific sampling and possibly DNA analysis to determine the animal source of the *E. coli* bacteria.

Margin of Safety

Streambank sediment and bacteria loading analyses included a 10% margin of safety by removing 10% of the loading capacity from consideration. Reach 5 calculations of sediment loading did not have a 10% MOS removed because the erosion inventory was based on an area further downstream that is likely to have greater erosion. Thus, an implicit margin of safety is contained within the erosion inventory for Reach 5. For temperature, an inherent margin of safety is implied as no better shade conditions are considered achievable.

Seasonal Variation

Sediment delivery to a stream is highly coupled to seasonal events. The majority of bank erosion and sediment delivery occurs during high runoff, high flow events associated with spring snowmelt and rains. It is often difficult to monitor these events, thus sediment loading analysis is based on sediment delivery from streambanks integrated over an entire year.

Temperature problems are associated with the certain times of the year that water quality criteria for temperature apply. Water temperatures increase in response to warming air temperatures in spring and summer. Critical time periods for water temperature are during spring and fall salmonid spawning time periods, as well as during peak temperatures in mid summer. Effective shade and its associated riparian community and bank stability, helps keep water cool during warming trends in spring summer and early fall.

Bacterial contamination in streams can be highly variable depending on types of releases, the bacteria's short lived nature, and seasonal hydrology. The summer sampling that has occurred, the results of which have been used in this loading analysis, may be the result of summer low flow conditions. One cannot conclude from these data that *E. coli* contamination is high during other times of the year. Much more sampling is needed to adequately characterize the nature of bacterial contamination throughout the year.

Reasonable Assurance

All allocations are directed at nonpoint source activities. There are no known point sources in this portion of the Hangman Creek watershed. Sediment loading is based on streambank erosion inventories. All future monitoring should include streambank erosion inventories in affected reaches. Additional monitoring to verify impacts to or improvements of beneficial uses can include depth fines monitoring in spawning gravels.

Temperature monitoring should include measurements of effective shade and water temperature continuous recording instruments in affected reaches.

Bacteria monitoring should expand to include all times of the year, more site specific monitoring in an effort to locate specific sources of bacteria, and DNA analysis to determine animal origin of bacteria.

Background

Sediment and temperature TMDLs are based on the concept of meeting background conditions. Sediment targets (80% bank stability) that erosion inventories are based on imply that streambanks are 80% stable under natural conditions. There is no allowance in this sediment TMDL for disturbance of streambanks above background conditions. Temperature targets are based on achieving potential natural vegetation effective shade levels. There is no allowance in this temperature TMDL for disturbance of riparian shade above these natural conditions.

The bacteria TMDL is based on existing water quality standards to protect recreation uses of these waterbodies. Background bacteria conditions are unknown but should be investigated. *E. coli* TMDL levels should be adjusted based on source of the bacterium.

Reserve

No reserves for future pollutant additions have been made in these TMDLs. All pollutant levels are based on achieving background riparian and streambank conditions or achieving bacterial standards.

Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge storm water to a water body or to a municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites. In the past storm water was treated as a non-point source of pollutants. However, because storm water can be managed on site through management practices or when discharged through a discrete conveyance such as a storm sewer, it now requires a National Pollution Discharge Elimination System (NPDES) Permit.

The Construction General Permit (CGP)

If a construction project disturbs more than one acre of land (or is part of larger common development) that will disturb more than one acre), the operator is required to apply for permit coverage from EPA after developing a site-specific Storm Water Pollution Prevention Plan.

Storm Water Pollution Prevention Plan (SWPPP)

In order to obtain the Construction General Permit operators must develop a site-specific Storm Water Pollution Prevention Plan. The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically and maintain the best management practices (BMPs) through the life of the project

Construction Storm Water Requirements

When a stream is on Idaho's § 303(d) list and has a TMDL developed DEQ now incorporates a gross waste load allocation (WLA) for anticipated construction storm water activities. TMDLs developed in the past that did not have a WLA for construction storm water activities will also be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate Best Management Practices.

Typically there are specific requirements you must follow to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction storm water management. Sediment is usually the main pollutant of concern in storm water from construction sites. The application of specific best management practices from *Idaho's Catalog of Storm Water Best Management Practices for Idaho Cities and Counties* is generally sufficient to meet the standards and requirements of the General Construction Permit, unless local ordinances have more stringent and site specific standards that are applicable.

Remaining Available Load

Activities and nonpoint sources affecting streambank erosion are allocated a 55% reduction in sediment loading from streambanks throughout the watershed above the Tribal boundary. Individual streams have varying erosion reductions as described in Table 10a.

Activities and nonpoint sources affecting riparian shade and solar loading are allocated 15% to 70% reductions in solar load depending on locations as specified in Tables 11 through 16.

Activities and nonpoint sources affecting *E. coli* contamination are allocated 15% to 85% reductions in *E. coli* loadings depending on location and timing.

Table 18. Nonpoint source load allocations for upper Hangman Creek watershed.

Source	Pollutant	Allocation	Time Frame for Meeting Allocations
Streambanks	Sediment	55% reduction	2015
Roads and Mass Failure	Sediment	50% reduction	2015
Solar Load/Riparian Shade	Temperature	15% to 70% reductions	2025
Livestock/septic systems	Bacteria (*E. coli*)	15% to 85% reductions	2010

5.5 Implementation Strategies

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

Time Frame

Approach

Responsible Parties

Monitoring Strategy

5.6 Conclusions

Water body assessment unit # ID17010306PN001_02 includes tributaries to Hangman Creek (Bunnel Creek, Hill Creek, South Fork Hangman Creek, Martin Creek, Conrad Creek, etc.) and Hangman Creek itself above the confluence with South Fork Hangman Creek. This assessment unit was assessed in 2002 and listed for temperature. Water body assessment unit

ID17010306PN001_03 includes the mainstem Hangman Creek from its confluence with the South Fork Hangman Creek on downstream into the Coeur d'Alene Tribe Reservation. This assessment unit retained the original 1998 303d listing for habitat alteration, sediment, bacteria, and nutrients. Due to downstream conditions and the availability of recent data, it was decided that all listed pollutants would be analyzed in all streams, Hangman Creek proper from its source to the Tribal boundary and all associated tributaries found on a 1:100K hydrography.

No TMDL was completed for habitat alteration as a matter of DEQ policy. Additionally, due to recent data showing low levels of total phosphorus, it is recommended that this portion of the Hangman Creek watershed be de-listed for nutrients. TMDLs have been completed on all streams for sediment and temperature, and on Hangman Creek and its South Fork for bacteria.

Table 19. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
ID17010306PN001_02	Sediment, Bacteria, Temperature	Yes	Previously only listed for Temperature	Recent data and downstream conditions
ID17010306PN001_03	Sediment, Bacteria, Temperature	Yes	Previously listed for Habitat Alteration, Sediment, Bacteria, and Nutrients	Recent data
ID17010306PN001_03	Nutrients	No	De-list	Recent data

References Cited

The following references are references cited in the boilerplate language and in the glossary. Do not delete any of these references. Add all references you cite using the references listed below as examples or following the Council of Biology Editors (CBE) or another common format, as discussed in the guidance document.

American Geological Institute. 1962. Dictionary of geological terms. Doubleday and Company. Garden City, NY. 545 p.

Armantrout, N.B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society. Bethesda, MD. 136 p.

Batt, P.E. 1996. Governor Philip E. Batt's Idaho bull trout conservation plan. State of Idaho, Office of the Governor. Boise, ID. 20 p + appendices.

Bauer, S. and T. Wilson. 1983. Assessment of Nonirrigated Cropland Runoff, Hangman Creek, Benewah County, 1981-1982. Water Quality Status Report No. WQ-51. Idaho Department of Health and Welfare, Division of Environment. Boise, ID. 124p.

BSWCD. 1981. Hangman Creek Application, Idaho Agricultural Water Quality Program. Benewah Soil & Water Conservation District.

Clean Water Act (Federal water pollution control act), 33 U.S.C. § 1251-1387. 1972.

Denny, P. 1980. Solute movement in submerged angiosperms. Biology Review. 55:65-92.

EPA. 1996. Biological criteria: technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water. Washington, DC. 162 p.

Franson, M.A.H., L.S. Clesceri, A.E. Greenberg, and A.D. Eaton, editors. 1998. Standard methods for the examination of water and wastewater, twentieth edition. American Public Health Association. Washington, DC. 1,191 p.

Fortis, B. and M. Hartz. 1991. Hangman Creek: Post-Best Management Practices Implementation Study, Benewah County, Idaho, 1989-1990. Water Quality Status Report No. 95. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, ID. 60p.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D.T. Mosier. 2002. The Idaho Department of Environmental Quality water body assessment guidance, second edition-final. Department of Environmental Quality. Boise, ID. 114 p.

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference condition. In: Davis, W.S. and T.P. Simon, editors. Biological assessment and criteria: tools for water resource planning and decision making. CRC Press. Boca Raton, FL. p 31-48.

Idaho Code § 39.3611. Development and implementation of total maximum daily load or equivalent processes.

Idaho Code § 39.3615. Creation of watershed advisory groups.

IDAPA 58.01.02. Idaho water quality standards and wastewater treatment requirements.

IDEQ. 2002. Middle Salmon River-Chamberlain Creek Subbasin Assessment and Crooked Creek TMDL. Idaho Department of Environmental Quality. Boise, ID. 207p.

IDL. 2000. Forest Practices Cumulative Watershed Effects Process for Idaho. Idaho Department of Lands, Boise, ID.

IDL. 2003. Hangman Creek Headwaters (HUC Nos. 17010306 – 1003) WQLS 3566 Cumulative Watershed Effects Assessment. Idaho Department of Lands. Coeur d'Alene, ID. 26p.

Karr, J.R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1:66-84.

McGreer, D. 1998. Personal Communication as cited in Appendix C of St Joe River Subbasin Assessment and TMDLs, Idaho Department of Environmental Quality, July 2003.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. Volume 16(4): 693-727.

NRCS. 2001. Official Series Descriptions. http://soils.usda.gov/ technical/classification/osd/index.html

Overton, C.K., J.D. McIntyre, R. Armstrong, S.L. Whitwell, and K.A. Duncan. 1995. User's guide to fish habitat: descriptions that represent natural conditions in the Salmon River basin, Idaho. U.S. Forest Service, Intermountain Research Station, General Technical Report INT-GTR-322, Ogden, UT.

OWEB. 2001. Addendum to Water Quality Monitoring Technical Guide Book: Chapter 14 Stream Shade and Canopy Cover Methods. Oregon's Watershed Enhancement Board. Salem, OR. 35p.

Rand, G.W., editor. 1995. Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment, second edition. Taylor and Francis. Washington, DC. 1,125 p.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO 378p.

SCS. 1994. Preliminary Investigation Report, Hangman Creek Watershed, Benewah County, Idaho. USDA Soil Conservation Service and Benewah Soil and Water Conservation District. 22p plus appendices.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Transactions American Geophysical Union 38:913-920.

USDA. 1999. A procedure to estimate the response of aquatic systems to changes in phosphorus and nitrogen inputs. National Water and Climate Center, Natural Resources Conservation Service. Portland, OR.

USEPA. 1986. Quality Criteria for Water. US Environmental Protection Agency. Washington, D.C.

USEPA. 2000. Ambient Water Quality Criteria Recommendations; Rivers and Streams in Nutrient Ecoregion III. EPA822-B-00-016. US Environmental Protection Agency. Washington, D.C.

USGS. 1987. Hydrologic unit maps. Water supply paper 2294. United States Geological Survey. Denver, CO. 63 p.

Washington Forest Practices Board. 1995. Board manual: standard methodology for conducting watershed analysis under Chapter 222-22 WAC Version 3.0.

Water Environment Federation. 1987. The Clean Water Act of 1987. Water Environment Federation. Alexandria, VA. 318 p.

Water Quality Act of 1987, Public Law 100-4. 1987.

Water quality planning and management, 40 CFR Part 130.

WDOE and SCCD. 1994. Hangman Creek Watershed (also known as Latah Creek) Management Plan. Washington Department of Ecology and Spokane County Conservation District. 162p.

Wetzel, R.G. 1983. Limnology. Saunders College Publishing. New York, NY.

Weisel, C.J. 1980. Soil Survey of Benewah County Area, Idaho. USDA SCS, USDI BIA, and Univ. of Idaho Agricultural Experiment Station.

GIS Coverages

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Glossary

305(b)

Refers to section 305 subsection “b” of the Clean Water Act. The term “305(b)” generally describes a report of each state’s water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

§303(d)

Refers to section 303 subsection “d” of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Acre-foot

A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers.

Adsorption

The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules

Aeration

A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.

Aerobic

Describes life, processes, or conditions that require the presence of oxygen.

Adfluvial

Describes fish whose life history involves seasonal migration from lakes to streams for spawning.

Adjunct

In the context of water quality, adjunct refers to areas directly adjacent to focal or refuge habitats that have been degraded by human or natural disturbances and do not presently support high diversity or abundance of native species.

Alevin	A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.
Algae	Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.
Alluvium	Unconsolidated recent stream deposition.
Ambient	General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).
Anadromous	Fish, such as salmon and sea-run trout, that live part or the majority of their lives in the saltwater but return to fresh water to spawn.
Anaerobic	Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.
Anoxia	The condition of oxygen absence or deficiency.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Anti-Degradation	Refers to the U.S. Environmental Protection Agency’s interpretation of the Clean Water Act goal that states and tribes maintain, as well as restore, water quality. This applies to waters that meet or are of higher water quality than required by state standards. State rules provide that the quality of those high quality waters may be lowered only to allow important social or economic development and only after adequate public participation (IDAPA 58.01.02.051). In all cases, the existing beneficial uses must be maintained. State rules further define lowered water quality to be 1) a measurable change, 2) a change adverse to a use, and 3) a change in a pollutant relevant to the water’s uses (IDAPA 58.01.02.003.61).

Aquatic

Occurring, growing, or living in water.

Aquifer

An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.

Assemblage (aquatic)

An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).

Assessment Database (ADB)

The ADB is a relational database application designed for the U.S. Environmental Protection Agency for tracking water quality assessment data, such as use attainment and causes and sources of impairment. States need to track this information and many other types of assessment data for thousands of water bodies and integrate it into meaningful reports. The ADB is designed to make this process accurate, straightforward, and user-friendly for participating states, territories, tribes, and basin commissions.

Assessment Unit (AU)

A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.

Assimilative Capacity

The ability to process or dissipate pollutants without ill effect to beneficial uses.

Autotrophic

An organism is considered autotrophic if it uses carbon dioxide as its main source of carbon. This most commonly happens through photosynthesis.

Batholith

A large body of intrusive igneous rock that has more than 40 square miles of surface exposure and no known floor. A batholith usually consists of coarse-grained rocks such as granite.

Bedload

Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.

Beneficial Use

Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Beneficial Use Reconnaissance Program (BURP)

A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers

Benthic

Pertaining to or living on or in the bottom sediments of a water body

Benthic Organic Matter.

The organic matter on the bottom of a water body.

Benthos

Organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the lake and stream bottoms.

Best Management Practices (BMPs)

Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Best Professional Judgment

A conclusion and/or interpretation derived by a trained and/or technically competent individual by applying interpretation and synthesizing information.

Biochemical Oxygen Demand (BOD)

The amount of dissolved oxygen used by organisms during the decomposition (respiration) of organic matter, expressed as mass of oxygen per volume of water, over some specified period of time.

Biological Integrity

1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).

Biomass	The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.
Biota	The animal and plant life of a given region.
Biotic	A term applied to the living components of an area.
Clean Water Act (CWA)	The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.
Coliform Bacteria	A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).
Colluvium	Material transported to a site by gravity.
Community	A group of interacting organisms living together in a given place.
Conductivity	The ability of an aqueous solution to carry electric current, expressed in micro (μ) mhos/centimeter at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.
Cretaceous	The final period of the Mesozoic era (after the Jurassic and before the Tertiary period of the Cenozoic era), thought to have covered the span of time between 135 and 65 million years ago.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per

year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.

Cubic Feet per Second

A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

Cultural Eutrophication

The process of eutrophication that has been accelerated by human-caused influences. Usually seen as an increase in nutrient loading (also see Eutrophication).

Culturally Induced Erosion

Erosion caused by increased runoff or wind action due to the work of humans in deforestation, cultivation of the land, overgrazing, and disturbance of natural drainages; the excess of erosion over the normal for an area (also see Erosion).

Debris Torrent

The sudden down slope movement of soil, rock, and vegetation on steep slopes, often caused by saturation from heavy rains.

Decomposition

The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.

Depth Fines

Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 millimeters depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 centimeters).

Designated Uses

Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.

Discharge

The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen (DO)	The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.
Disturbance	Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.
E. coli	Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.
Ecology	The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.
Ecological Indicator	A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework.
Ecological Integrity	The condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes (EPA 1996).
Ecosystem	The interacting system of a biological community and its non-living (abiotic) environmental surroundings.
Effluent	A discharge of untreated, partially treated, or treated wastewater into a receiving water body.
Endangered Species	Animals, birds, fish, plants, or other living organisms threatened with imminent extinction. Requirements for declaring a species as endangered are contained in the Endangered Species Act.

Environment

The complete range of external conditions, physical and biological, that affect a particular organism or community.

Eocene

An epoch of the early Tertiary period, after the Paleocene and before the Oligocene.

Eolian

Windblown, referring to the process of erosion, transport, and deposition of material by the wind.

Ephemeral Stream

A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from melting snow or other sources. Its channel is at all times above the water table (American Geological Institute 1962).

Erosion

The wearing away of areas of the earth's surface by water, wind, ice, and other forces.

Eutrophic

From Greek for "well nourished," this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.

Eutrophication

1) Natural process of maturing (aging) in a body of water. 2) The natural and human-influenced process of enrichment with nutrients, especially nitrogen and phosphorus, leading to an increased production of organic matter.

Exceedance

A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

Existing Beneficial Use or Existing Use

A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

Exotic Species

A species that is not native (indigenous) to a region.

Extrapolation

Estimation of unknown values by extending or projecting from known values.

Fauna

Animal life, especially the animals characteristic of a region, period, or special environment.

Fecal Coliform Bacteria

Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

Fecal Streptococci

A species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.

Feedback Loop

In the context of watershed management planning, a feedback loop is a process that provides for tracking progress toward goals and revising actions according to that progress.

Fixed-Location Monitoring

Sampling or measuring environmental conditions continuously or repeatedly at the same location.

Flow

See *Discharge*.

Fluvial

In fisheries, this describes fish whose life history takes place entirely in streams but migrate to smaller streams for spawning.

Focal

Critical areas supporting a mosaic of high quality habitats that sustain a diverse or unusually productive complement of native species.

Fully Supporting

In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Fully Supporting Cold Water

Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

Fully Supporting but Threatened

An intermediate assessment category describing water bodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a "not fully supporting" status.

Geographical Information Systems (GIS)

A georeferenced database.

Geometric Mean

A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.

Grab Sample

A single sample collected at a particular time and place. It may represent the composition of the water in that water column.

Gradient

The slope of the land, water, or streambed surface.

Ground Water

Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.

Growth Rate

A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.

Habitat

The living place of an organism or community.

Headwater

The origin or beginning of a stream.

Hydrologic Basin

The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).

Hydrologic Cycle

The cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Atmospheric moisture, clouds, rainfall, runoff, surface water, ground water, and water infiltrated in soils are all part of the hydrologic cycle.

Hydrologic Unit

One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

Hydrologic Unit Code (HUC)

The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

Hydrology

The science dealing with the properties, distribution, and circulation of water.

Impervious

Describes a surface, such as pavement, that water cannot penetrate.

Influent

A tributary stream.

Inorganic

Materials not derived from biological sources.

Instantaneous

A condition or measurement at a moment (instant) in time.

Intergravel Dissolved Oxygen

The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.

Intermittent Stream

1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. 2) A stream that has a period of zero flow for at least one week during most years.

Interstate Waters

Waters that flow across or form part of state or international boundaries, including boundaries with Native American nations.

Irrigation Return Flow	Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams.
Key Watershed	A watershed that has been designated in Idaho Governor Batt's *State of Idaho Bull Trout Conservation Plan* (1996) as critical to the long-term persistence of regionally important trout populations.
Knickpoint	Any interruption or break of slope.
Land Application	A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge.
Limiting Factor	A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.
Limnology	The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.
Load Allocation (LA)	A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Load(ing) Capacity (LC)	A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.

Loess	A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.
Lotic	An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth.
Luxury Consumption	A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants' current needs.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Macrophytes	Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp.*), are free-floating forms not rooted in sediment.
Margin of Safety (MOS)	An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.
Mass Wasting	A general term for the down slope movement of soil and rock material under the direct influence of gravity.
Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Median	The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two

middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11.

Metric

1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)

A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm).

Million Gallons per Day (MGD)

A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Miocene

Of, relating to, or being an epoch of, the Tertiary between the Pliocene and the Oligocene periods, or the corresponding system of rocks.

Monitoring

A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

Mouth

The location where flowing water enters into a larger water body.

National Pollution Discharge Elimination System (NPDES)

A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition

The condition that exists with little or no anthropogenic influence.

Nitrogen

An element essential to plant growth, and thus is considered a nutrient.

Nodal

Areas that are separated from focal and adjunct habitats, but serve critical life history functions for individual native fish.

Nonpoint Source

A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Not Assessed (NA)

A concept and an assessment category describing water bodies that have been studied, but are missing critical information needed to complete an assessment.

Not Attainable

A concept and an assessment category describing water bodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

Not Fully Supporting

Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Not Fully Supporting Cold Water

At least one biological assemblage has been significantly modified beyond the natural range of its reference condition.

Nuisance

Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient

Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Nutrient Cycling

The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic

The Greek term for “poorly nourished.” This describes a body of water in which productivity is low and nutrients are limiting to algal growth, as typified by low algal density and high clarity.

Organic Matter

Compounds manufactured by plants and animals that contain principally carbon.

Orthophosphate

A form of soluble inorganic phosphorus most readily used for algal growth.

Oxygen-Demanding Materials

Those materials, mainly organic matter, in a water body that consume oxygen during decomposition.

Parameter

A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.

Partitioning

The sharing of limited resources by different races or species; use of different parts of the habitat, or the same habitat at different times. Also the separation of a chemical into two or more phases, such as partitioning of phosphorus between the water column and sediment.

Pathogens

A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Perennial Stream

A stream that flows year-around in most years.

Periphyton

Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants.

Pesticide

Substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

pH	The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.
Phased TMDL	A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a water body. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.
Phosphorus	An element essential to plant growth, often in limited supply, and thus considered a nutrient.
Physiochemical	In the context of bioassessment, the term is commonly used to mean the physical and chemical factors of the water column that relate to aquatic biota. Examples in bioassessment usage include saturation of dissolved gases, temperature, pH, conductivity, dissolved or suspended solids, forms of nitrogen, and phosphorus. This term is used interchangeable with the term “physical/chemical.”
Plankton	Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.
Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Pollution	A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical,

	biological, chemical, and radiological integrity of water and other media.
Population	A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.
Pretreatment	The reduction in the amount of pollutants, elimination of certain pollutants, or alteration of the nature of pollutant properties in wastewater prior to, or in lieu of, discharging or otherwise introducing such wastewater into a publicly owned wastewater treatment plant.
Primary Productivity	The rate at which algae and macrophytes fix carbon dioxide using light energy. Commonly measured as milligrams of carbon per square meter per hour.
Protocol	A series of formal steps for conducting a test or survey.
Qualitative	Descriptive of kind, type, or direction.
Quality Assurance (QA)	A program organized and designed to provide accurate and precise results. Included are the selection of proper technical methods, tests, or laboratory procedures; sample collection and preservation; the selection of limits; data evaluation; quality control; and personnel qualifications and training (Rand 1995). The goal of QA is to assure the data provided are of the quality needed and claimed (EPA 1996).
Quality Control (QC)	Routine application of specific actions required to provide information for the quality assurance program. Included are standardization, calibration, and replicate samples (Rand 1995). QC is implemented at the field or bench level (EPA 1996).
Quantitative	Descriptive of size, magnitude, or degree.
Reach	A stream section with fairly homogenous physical characteristics.
Reconnaissance	An exploratory or preliminary survey of an area.

Reference

A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.

Reference Condition

1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).

Reference Site

A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.

Representative Sample

A portion of material or water that is as similar in content and consistency as possible to that in the larger body of material or water being sampled.

Resident

A term that describes fish that do not migrate.

Respiration

A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riffle

A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.

Riparian

Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.

Riparian Habitat Conservation Area (RHCA)

A U.S. Forest Service description of land within the following number of feet up-slope of each of the banks of streams:

- 300 feet from perennial fish-bearing streams
- 150 feet from perennial non-fish-bearing streams
- 100 feet from intermittent streams, wetlands, and ponds in priority watersheds.

River	A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.
Runoff	The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Settleable Solids	The volume of material that settles out of one liter of water in one hour.
Species	1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.
Spring	Ground water seeping out of the earth where the water table intersects the ground surface.
Stagnation	The absence of mixing in a water body.
Stenothermal	Unable to tolerate a wide temperature range.
Stratification	A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).
Stream	A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.

Storm Water Runoff

Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the stream. The water often carries pollutants picked up from these surfaces.

Stressors

Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Subbasin

A large watershed of several hundred thousand acres. This is the name commonly given to 4th field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)

A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed

A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units.

Surface Fines

Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 millimeters depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.

Surface Runoff

Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.

Surface Water

All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Suspended Sediments

Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Taxon

Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).

Tertiary

An interval of geologic time lasting from 66.4 to 1.6 million years ago. It constitutes the first of two periods of the Cenozoic Era, the second being the Quaternary. The Tertiary has five subdivisions, which from oldest to youngest are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs.

Thalweg

The center of a stream's current, where most of the water flows.

Threatened Species

Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Total Maximum Daily Load (TMDL)

A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Dissolved Solids

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Toxic Pollutants

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Tributary

A stream feeding into a larger stream or lake.

Trophic State

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

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Turbidity

A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Vadose Zone

The unsaturated region from the soil surface to the ground water table.

Wasteload Allocation (WLA)

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

Water Quality Limited

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Limited Segment (WQLS)

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."

Water Quality Management Plan

A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

Water Quality Modeling

The prediction of the response of some characteristics of lake or stream water based on mathematical relations of input variables such as climate, stream flow, and inflow water quality.

Water Quality Standards

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Table

The upper surface of ground water; below this point, the soil is saturated with water.

Watershed

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a water body.

Water Body Identification Number (WBID)

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

Wetland

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

Young of the Year

Young fish born the year captured, evidence of spawning activity.

Appendix A. Unit Conversion Chart

Table A-1. Metric - English unit conversions.

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Volume	Gallons (gal) Cubic Feet (ft^3)	Liters (L) Cubic Meters (m^3)	1 gal = 3.78 L 1 L= 0.26 gal 1 ft^3 = 0.03 m^3 1 m^3 = 35.32 ft^3	3 gal = 11.35 L 3 L = 0.79 gal 3 ft^3 = 0.09 m^3 3 m^3 = 105.94 ft^3
Flow Rate	Cubic Feet per Second (cfs)[a]	Cubic Meters per Second (m^3/sec)	1 cfs = 0.03 m^3/sec 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 °C = 37.4 °F

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.

[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

Appendix B. State and Site-Specific Standards and Criteria and Temperature Data Analysis

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring spawning salmonids, the default spawning and incubation period recognized by DEQ is generally from March 15th to July 1st each year (Grafe et al., 2002). Fall spawning can occur as early as August 15th and continue with incubation on into the following spring up to June 1st. As per IDAPA 58.01.02.250.02.e.ii., the water quality criteria that need to be met during that time period are:

> 13°C as a daily maximum water temperature,
>
> 9°C as a daily average water temperature.

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of highest annual MWMT air temperatures) is compared to the daily maximum criterion of 13°C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during these time periods. If potential natural vegetation targets are achieved yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401.*

Section 401 relates to point source wastewater treatment requirements. In this case if temperature criteria for any aquatic life use is exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3°C (IDAPA 58.01.02.401.03.a.v.).

Temperature Data versus Shade

Temperature data were available from the Coeur d'Alene Tribe for a variety of locations and streams in the upper Hangman Creek area. Graphs for the most recent continuous recordings are included in this appendix. In general, most sites had salmonids spawning criteria violation in the spring and fall during the default salmonids spawning period (March 15 to

July 15 for spring spawning and August 15 through October for fall spawning). Table B1 shows the percentage of time that daily maximum criteria (13C) violations occurred during these two seasons at the various recording sites. The exact location of temperature recorder placement is unknown, so general stream locations are provided. Only a few sites could be processed through DEQ's Tempdata spreadsheet to calculate daily average (9C) violations in that manner.

Table B1. Percent of Spawning Periods with Criteria Violations.

Stream Name and Location	Year	13C Criteria Violations (% of spring spawning period)	13C Criteria Violations (% of fall spawning period)	9C Criteria Violations (% of spring spawning period)	9C Criteria Violations (% of fall spawning period)
Martin Creek	2002	66.7	24.5		
Martin Creek	2004	25	18	55	58
Upper Hangman Creek	2002	27.8	n.a.		
Hangman Creek @ SF Road	2003	45	50		
Hangman Creek @ SF Road	2004	25	44		65
Lower SF Hangman Creek	2003	n.a.	0		
Lower SF Hangman Creek	2004	n.a.	23		56
Upper SF Hangman Creek	2002	0	0		
Upper SF Hangman Creek	2003	0	1.8		
Upper SF Hangman Creek	2004	n.a.	3		35
Hangman Forest	2003	38.9	38.7		
Hangman Forest	2004	15.4	13.8		

In order to determine the relationship between stream temperature and existing shade, these data on daily maximum (13C) criteria violations were used to compare to stream shade. A variety of shade parameters were examined (e.g. the stream's average existing shade, the stream's percent reduction in solar loading), however, the stream's lowest recorded existing shade value provided the best relationship (see Figures B1 and B2). Streams where the lowest existing shade is 60% had fewer days of violations then those streams where the lowest existing shade is 40%.

Figure B1. Percent Criteria Violations (13C) for the Fall Spawning Period versus Lowest Existing Shade

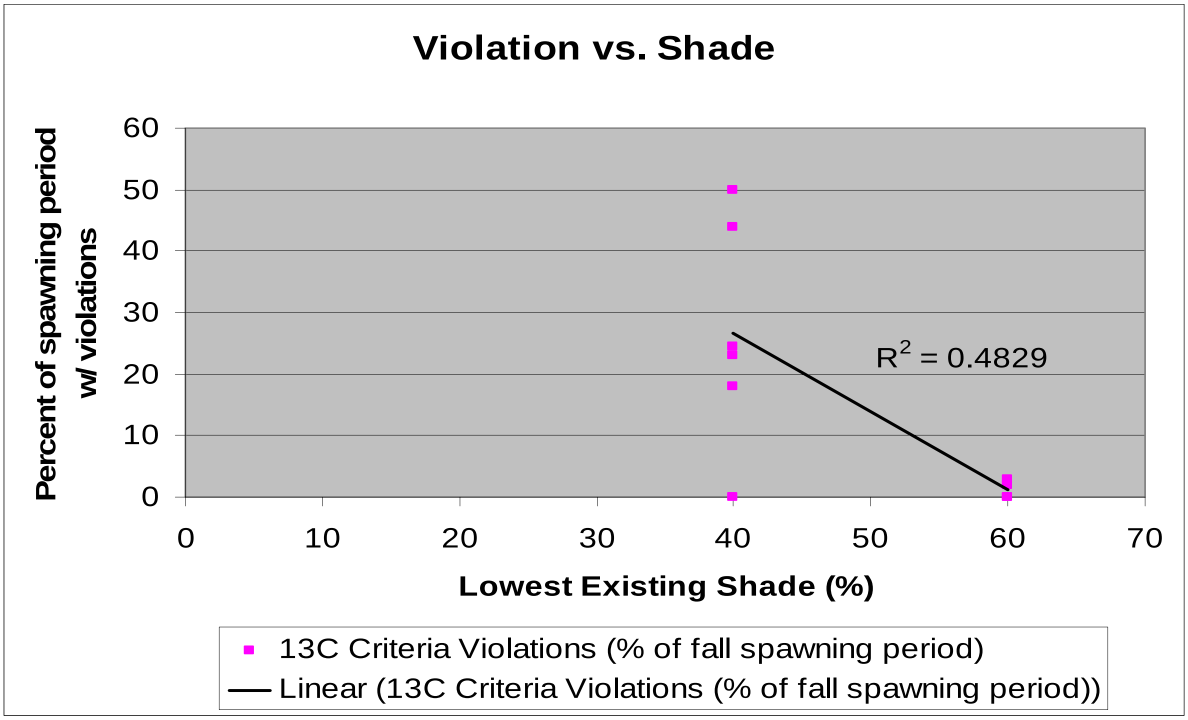
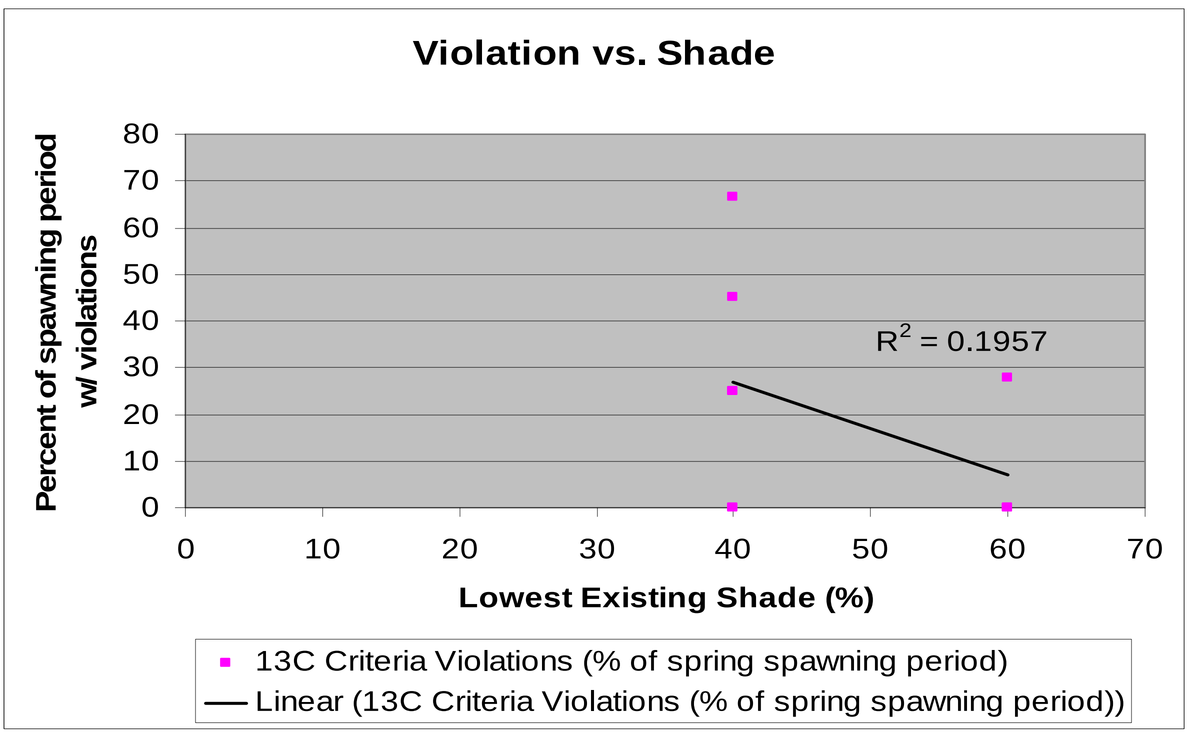
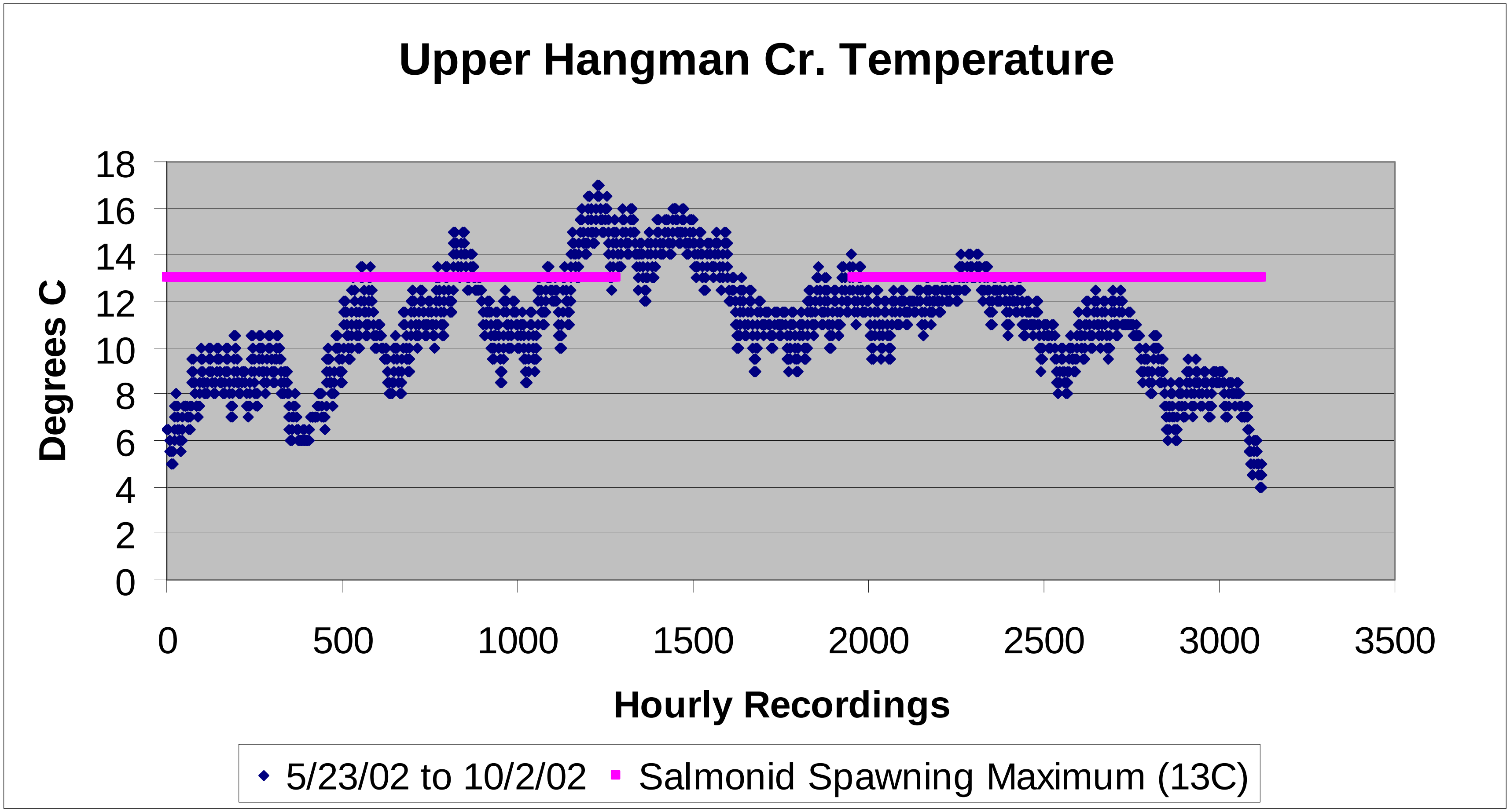
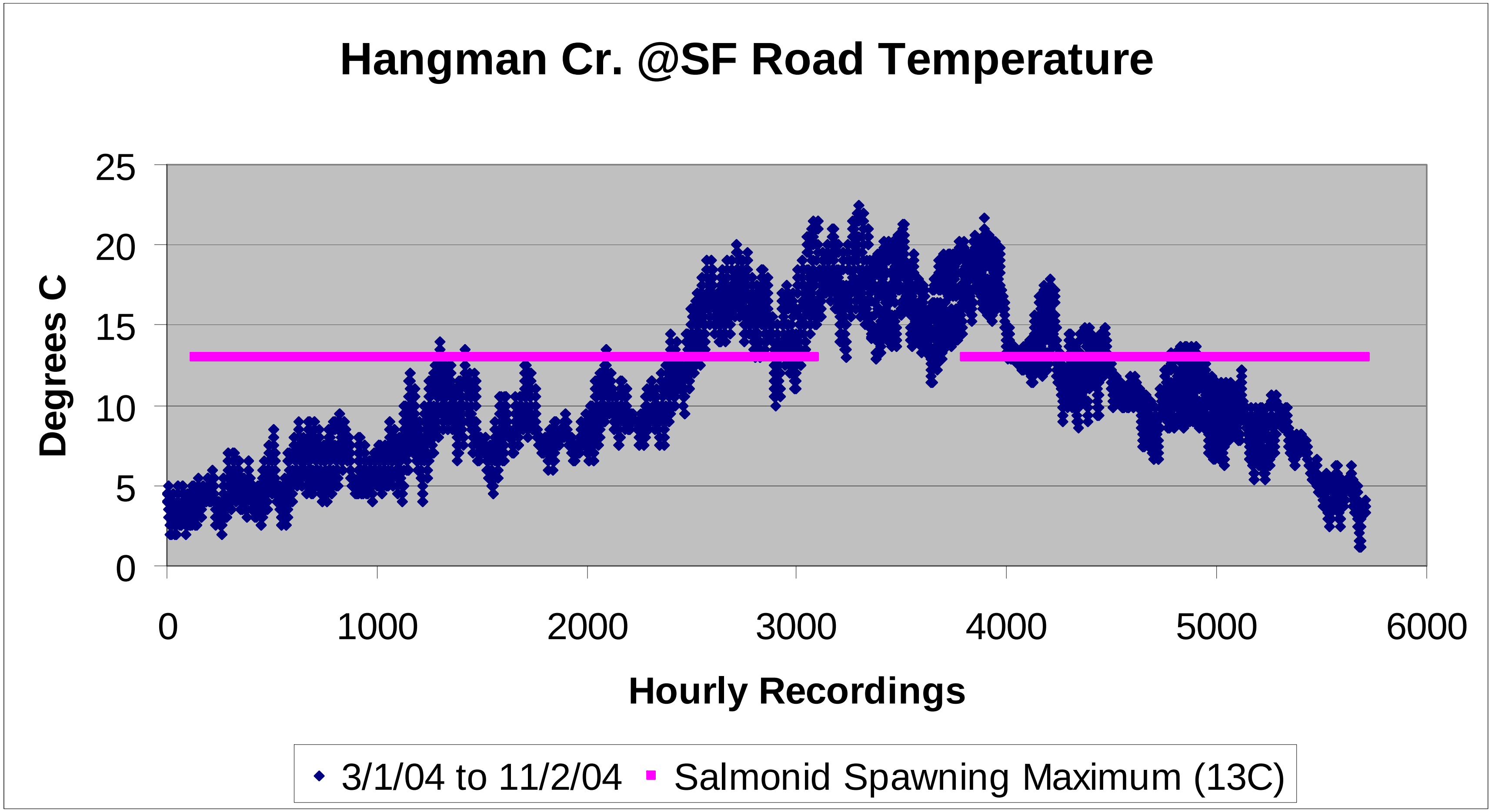
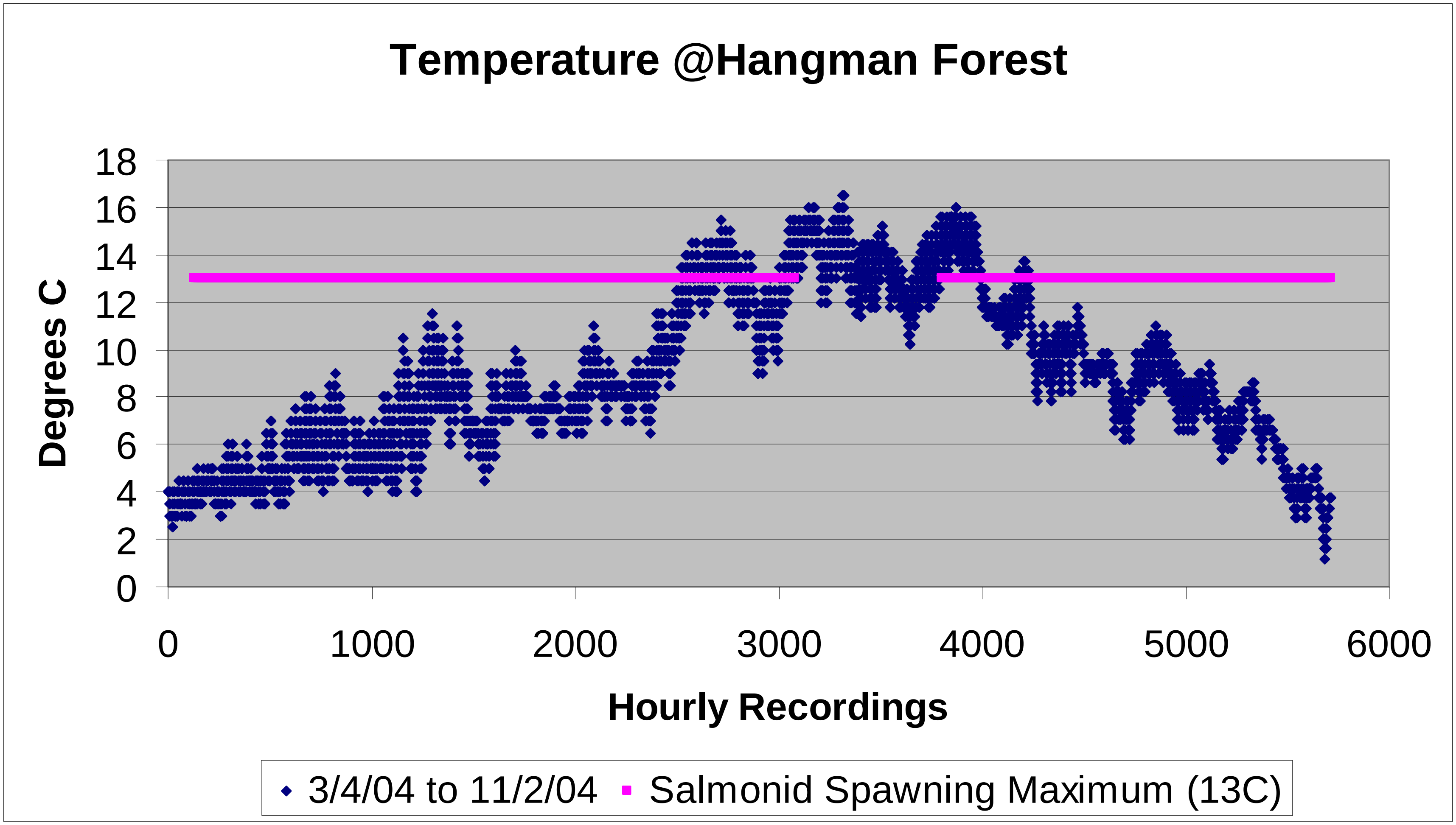


Figure B1. Percent Criteria Violations (13C) for the Spring Spawning Period versus Lowest Existing Shade

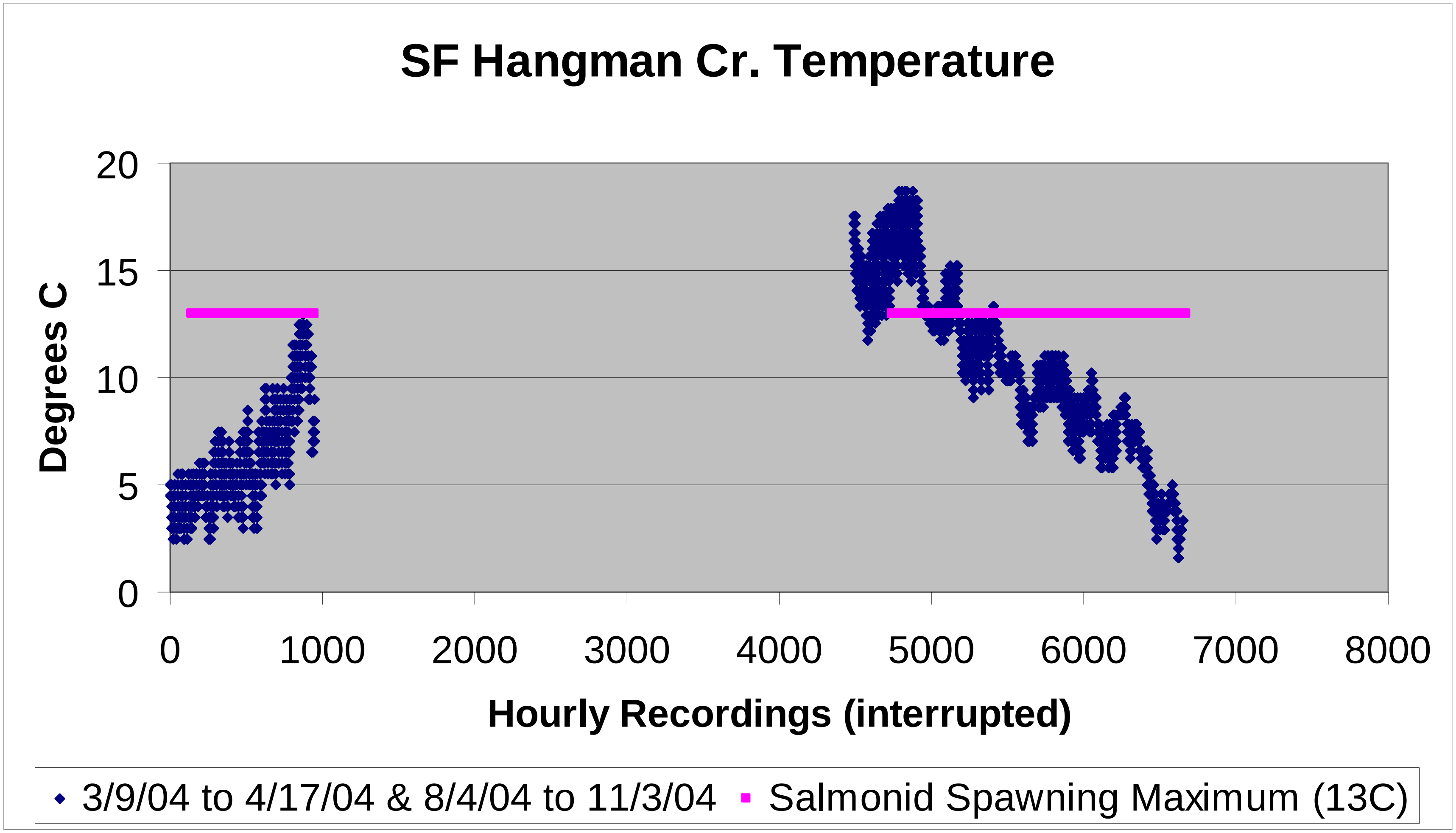



Upper Hangman Cr. Temperature
Degrees C
18
16
14
12
10
8
6
4
2
0
0
500
1000
1500
2000
2500
3000
3500
Hourly Recordings
5/23/02 to 10/2/02
Salmonid Spawning Maximum (13C)

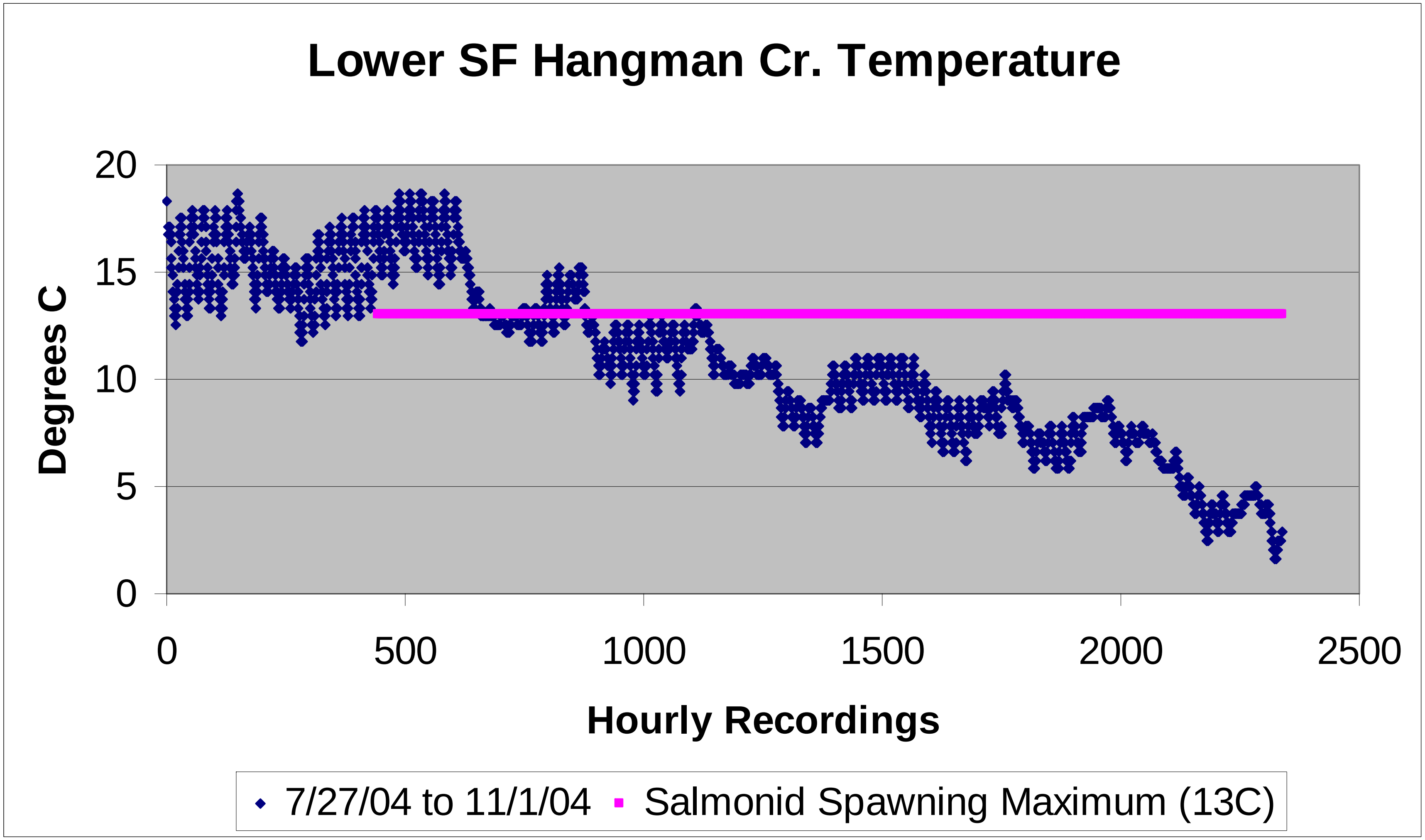

Hangman Cr. @SF Road Temperature
Degrees C
25
20
15
10
5
0
0
1000
2000
3000
4000
5000
6000
Hourly Recordings
3/1/04 to 11/2/04
Salmonid Spawning Maximum (13C)

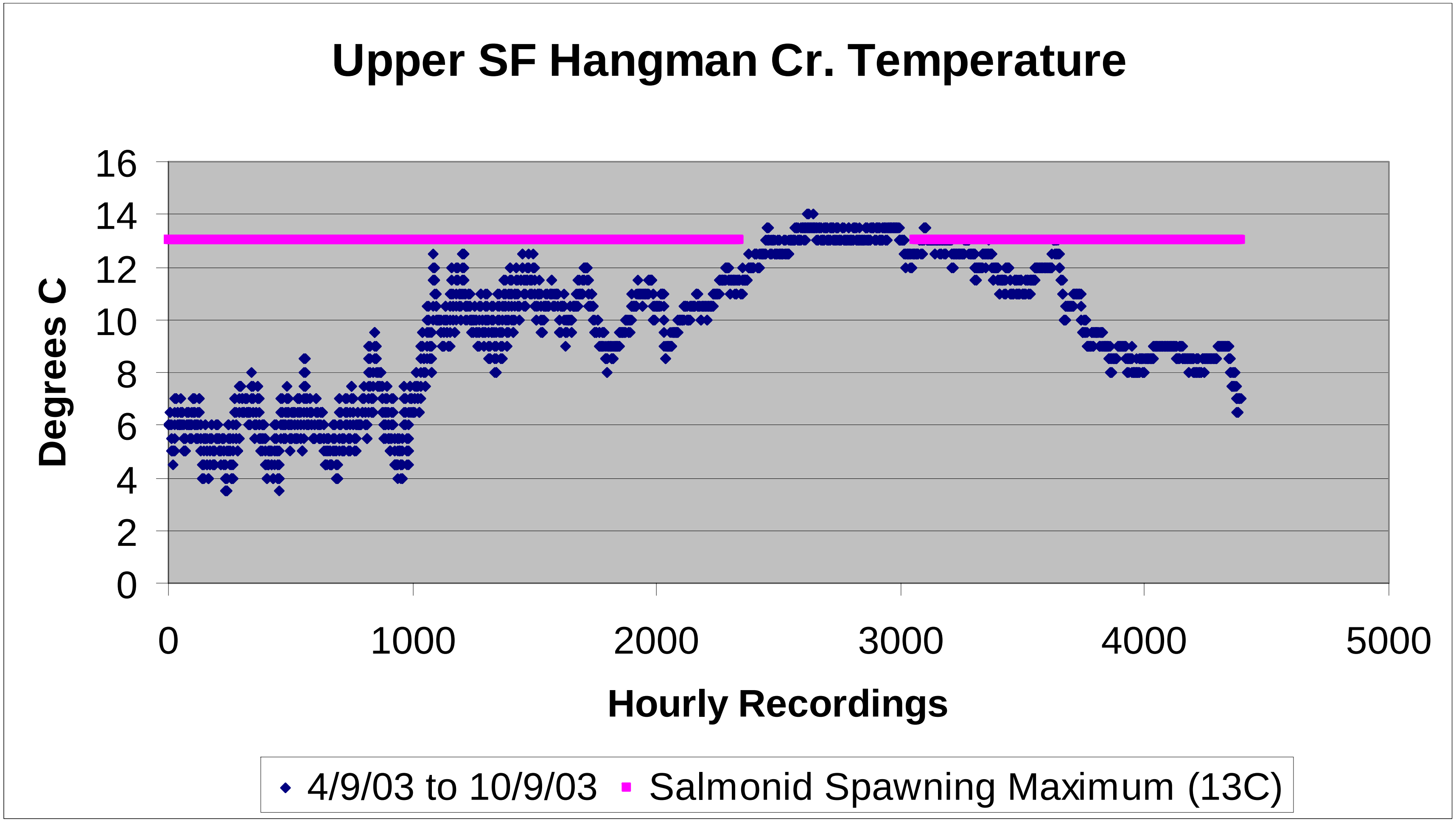


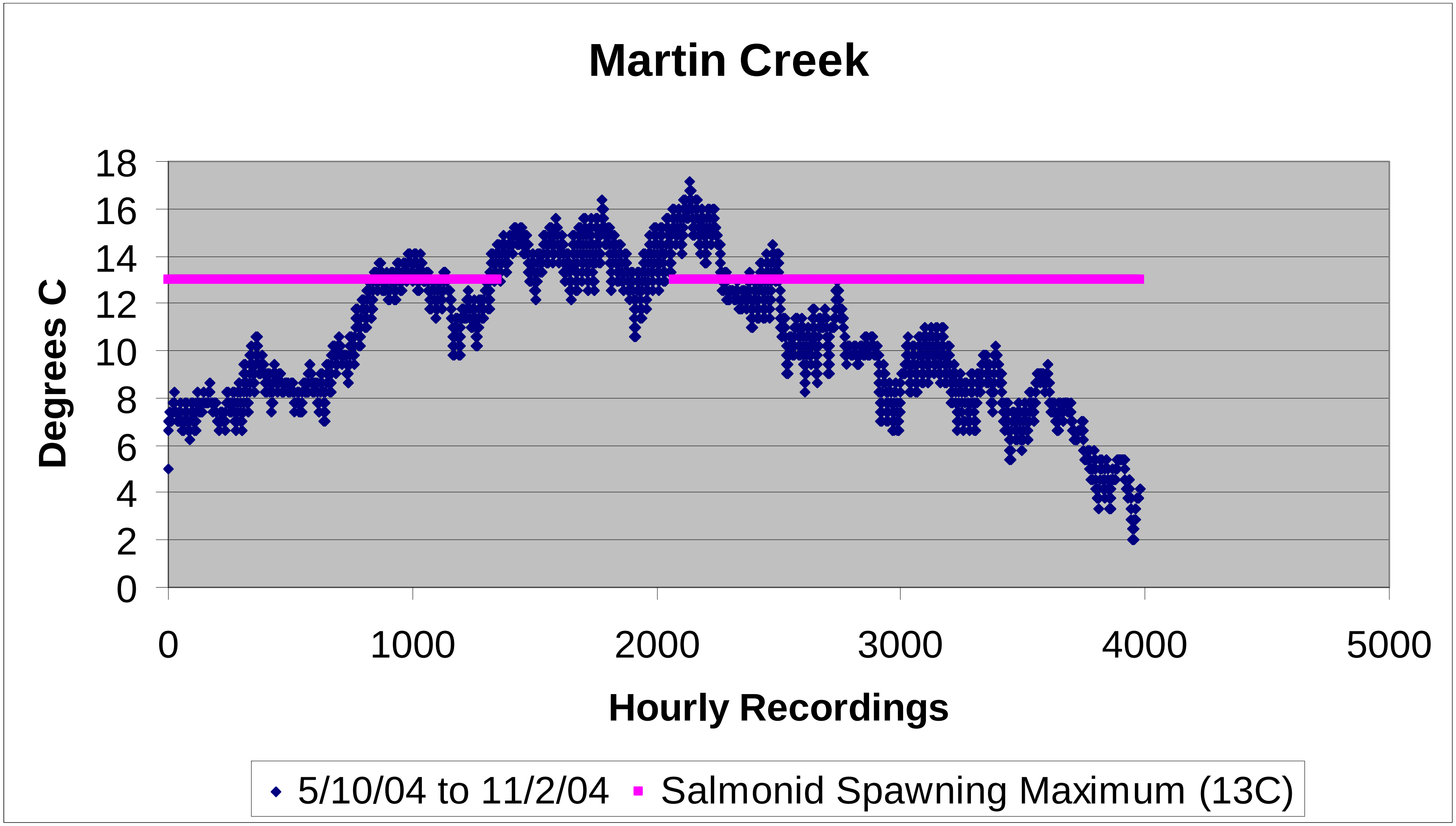
Temperature @Hangman Forest
Degrees C
0
2
4
6
8
10
12
14
16
18
0
1000
2000
3000
4000
5000
6000
Hourly Recordings
3/4/04 to 11/2/04
Salmonid Spawning Maximum (13C)



DRAFT 7/1/2005
Remove for final version


Lower SF Hangman Cr. Temperature
20
15
10
5
0
Degrees C
0
500
1000
1500
2000
2500
Hourly Recordings
7/27/04 to 11/1/04
Salmonid Spawning Maximum (13C)


Upper SF Hangman Cr. Temperature
Degrees C
16
14
12
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
Hourly Recordings
4/9/03 to 10/9/03
Salmonid Spawning Maximum (13C)


Martin Creek
Degrees C
18
16
14
12
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
Hourly Recordings
5/10/04 to 11/2/04
Salmonid Spawning Maximum (13C)

Appendix C. Data Sources and BURP Data

Table C-1. Data sources for upper Hangman Creek watershed Assessment.

Water Body	Data Source	Type of Data	When Collected
Hangman, SF Hangman, Tenas, Martin, Bunnel	Don Zaroban, IDEQ	Streambank erosion inventory	March 2005
Hangman, SF Hangman, Tenas, Martin, Bunnel	Don Zaroban, IDEQ	Solar pathfinder	March 2005
Hangman, SF Hangman	DEQ, CDARO	Bacteria	July, Aug. 2002
Hangman, SF Hangman, Martin	Coeur d'Alene Tribe	Temperature	2002-2004

BURPID	STREAM	ECOREGION	DATESAMPLED	SHI	BankCoverPercent	PercentFinesRaw	BankStabPercent	
2002SCDAA002	HANGMAN CREEK	COLUMBIA BASIN	7/2/2002	61	92.00	0.10	0.81	
2002SCDAA003	SOUTH FORK HANGMAN CREEK	COLUMBIA BASIN	7/2/2002	60	92.50	0.05	0.82	
2002SCDAA005	BUNNEL CREEK	NORTHERN ROCKIES	7/8/2002	70	94.50	0.18	0.96	
2003SCDAA002	SOUTH FORK HANGMAN CREEK	COLUMBIA BASIN	7/1/2003	74	60.00	0.09	0.99	
2003SCDAA005	MARTIN CREEK	NORTHERN ROCKIES	7/3/2003	50	48.00	0.49	0.76	
		BFHeightAvg	BFWidthAvg	Flow	PoolRiffleRatio	AvgWetDepth	AvgWetWidth	WDRatio
2002SCDAA002	HANGMAN CREEK	4.5	760.5	0.89	1.88	0.36	3.73	31.11
2002SCDAA003	SOUTH FORK HANGMAN CREEK	4.5	765.5	0.77	5.04	0.46	2.33	15.22
2002SCDAA005	BUNNEL CREEK	4.5	770.5	0.39	0.30	0.09	1.43	47.78
2003SCDAA002	SOUTH FORK HANGMAN CREEK	3	199.5	0.1	0.44	0.05	1.53	92.00
2003SCDAA005	MARTIN CREEK	3	203	0.2	0.34	0.08	2.00	75.00

BURPID	STREAM	Date Sampled	HUC	Total Abundance	Low Abund Flag	Taxa Richness	% Dom TopTaxa	% Dom Top3	% Dom Top5	% Scrapers	% EPT	Sum EPT Taxa	
2002SCDAA002	HANGMAN CREEK	7/2/2002	17010306	536		26	44.59	69.40	78.54	58.02	18.66	10	
2002SCDAA003	SOUTH FORK HANGMAN CREEK	7/2/2002	17010306	580		32	40.00	70.69	78.10	63.28	36.03	17	
2002SCDAA005	BUNNEL CREEK	7/8/2002	17010306	551		34	29.40	47.91	59.35	7.44	41.92	19	
2003SCDAA002	SOUTH FORK HANGMAN CREEK	7/1/2003	17010306	506		25	52.17	68.18	79.05	11.86	26.28	11	
2003SCDAA005	MARTIN CREEK	7/3/2003	17010306	505		26	37.82	63.76	73.66	45.94	79.41	14	

BURPID	STREAM	HBI	H Prime	% Ephem	% Plec	% Trich	Count Ephem Taxa	Count Plec Taxa	Count Trich Taxa	Sum Obligate CWB Taxa	Sum Obligate CWB	% Obligate CWB	# Clinger Taxa
2002SCDAA002	HANGMAN CREEK	6.42	1.02	14.37	3.36	0.93	6	1	3	1	13	2.43	9
2002SCDAA003	SOUTH FORK HANGMAN CREEK	6.67	1.06	30.52	3.28	2.24	9	3	5	1	5	0.86	13
2002SCDAA005	BUNNEL CREEK	5.70	1.37	12.89	24.32	4.72	9	7	3	3	22	3.99	16
2003SCDAA002	SOUTH FORK HANGMAN CREEK	5.13	1.28	13.64	10.47	2.17	4	4	3	4	6	1.19	12
2003SCDAA005	MARTIN CREEK	5.13	1.00	50.50	27.92	0.99	6	5	3	2	2	0.40	14

BURPID	STREAM	# Long Lived Taxa	% Clingers	% Long Lived	MBI	# Elmidae Taxa	# Predator Taxa	% Elmidae	% Predator	# Scrapers Taxa	SMI	TPI	Sum TPI Taxa
2002SCDAA002	HANGMAN CREEK	1	69.59	1.49	4.06	2	6	50.37	4.85	5	49.91	10.57	3
2002SCDAA003	SOUTH FORK HANGMAN CREEK	1	77.24	1.72	4.72	2	8	40.17	5.52	9	65.40	11.01	4
2002SCDAA005	BUNNEL CREEK	2	36.30	2.18	3.93	1	6	0.73	12.52	5	64.46	10.09	10
2003SCDAA002	SOUTH FORK HANGMAN CREEK	1	28.85	6.32	3.68	1	6	0.40	10.08	5	60.05	10.27	6
2003SCDAA005	MARTIN CREEK	2	63.56	1.98	4.21	2	6	1.39	22.97	5	54.25	10.85	7

Appendix D. Streambank Erosion Inventories

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Hangman Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 5		*Upstream:* 47.12043,-116.8278	
Date Collected:		4/28/2005	*Downstream:* 47.12138,-116.8304	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:** impacted brush	
Data Reduced By:	Mark Shumar		represents 960m of Hangman and 230m of SF	

Streambank Erosion Calculations

Average Bank Height	3.38	ft
Total Inventoried Bank Length	856	ft
Inventoried Bank to Bank Length	1712	ft
Erosive Bank Length	638	ft
Bank to Bank Eroding Segment Length	1276	ft
Percent Eroding Bank	0.7453271	%
Eroding Area	4312.88	ft^2
Recession Rate	0.61	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	118.388556	tons/year/sample reach
Erosion Rate (Er)	730.247168	tons/mile/year
Feet of similar stream type	2294	ft
Eroding Bank Extrapolation	4695.56075	ft
Total Streambank Erosion	435.658822	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
730.2471679	435.65882	195.953472	116.90406	73.1661442

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	1157.312	ft^2
Erosion over sampled reach (with load reduction (20%)	31.76821	tons/yr/sample
Erosion Rate	195.9535	tons/mile/year
Feet of Similar Stream Type	2294	ft
Eroding Bank Extrapoltation (with reduction)	1260	ft
Total Streambank Erosion	116.9041	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	2
Bank/Channel Shape - downcutting (0-3)	2
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	13
Recession Rate	**0.61**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	SF Hangman Creek		**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Reach 4		*Upstream:*	47.06642,-116.7846	
Date Collected:		4/28/2005	*Downstream:*	47.067588,-116.784	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:**	road,slash,forest	
Data Reduced By:	ark Shumar		represents 2700m of SF and 2000m of Hangman		

Streambank Erosion Calculations

Average Bank Height	1.27	ft
Total Inventoried Bank Length	681	ft
Inventoried Bank to Bank Length	1362	ft
Erosive Bank Length	134.5	ft
Bank to Bank Eroding Segment Length	269	ft
Percent Eroding Bank	0.19750367	%
Eroding Area	341.63	ft^2
Recession Rate	0.16	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	2.459736	tons/year/sample reach
Erosion Rate (Er)	19.0710809	tons/mile/year
Feet of similar stream type	14739	ft
Eroding Bank Extrapolation	6091.01322	ft
Total Streambank Erosion	55.6962248	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
19.07108088	55.696225	19.312128	56.400192	-1.26394052

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	345.948	ft^2
Erosion over sampled reach (with load reduction (20%)	2.490826	tons/yr/sample
Erosion Rate	19.31213	tons/mile/year
Feet of Similar Stream Type	14739	ft
Eroding Bank Extrapoltation (with reduction)	6168	ft
Total Streambank Erosion	56.40019	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	2
Bank Condition (0-3)	1
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	9
Recession Rate	**0.16**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	SF Hangman Creek	**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Reach 8	*Upstream:*	47.08323,-116.77227	
Date Collected:	4/29/2005	*Downstream:*	47.08402,-116.77214	
Field Crew:	Zaroban, Valverde & Clyne	**Landuse and Notes:**	brushy	
Data Reduced By:	Mark Shumar			

Streambank Erosion Calculations

Average Bank Height	2.5	ft
Total Inventoried Bank Length	594	ft
Inventoried Bank to Bank Length	1188	ft
Erosive Bank Length	181	ft
Bank to Bank Eroding Segment Length	362	ft
Percent Eroding Bank	0.3047138	%
Eroding Area	905	ft^2
Recession Rate	0.38	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	15.4755	tons/year/sample reach
Erosion Rate (Er)	137.56	tons/mile/year
Feet of similar stream type	6000	ft
Eroding Bank Extrapolation	4018.56566	ft
Total Streambank Erosion	171.793682	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
137.56	171.79368	90.288	112.7574	34.36464088

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	594	ft^2
Erosion over sampled reach (with load reduction (20%)	10.1574	tons/yr/sample
Erosion Rate	90.288	tons/mile/year
Feet of Similar Stream Type	6000	ft
Eroding Bank Extrapoltation (with reduction)	2637.6	ft
Total Streambank Erosion	112.7574	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	2
Bank Condition (0-3)	2
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	11
Recession Rate	**0.38**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Bunnel Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 7		*Upstream:* 47.12201,-116.73049	
Date Collected:		4/29/2005	*Downstream:* 47.12285,-116.73244	
Field Crew:	Zaroban et al.		**Landuse and Notes:** harvested forest	
Data Reduced By:	Mark Shumar			

Streambank Erosion Calculations

Average Bank Height	0.88	ft
Total Inventoried Bank Length	538	ft
Inventoried Bank to Bank Length	1076	ft
Erosive Bank Length	59	ft
Bank to Bank Eroding Segment Length	118	ft
Percent Eroding Bank	0.10966543	%
Eroding Area	103.84	ft^2
Recession Rate	0.05	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.23364	tons/year/sample reach
Erosion Rate (Er)	2.29297249	tons/mile/year
Feet of similar stream type	3400	ft
Eroding Bank Extrapolation	863.724907	ft
Total Streambank Erosion	1.71017532	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
2.292972491	1.7101753	4.18176	3.118896	-82.37288136

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	189.376	ft^2
Erosion over sampled reach (with load reduction (20%)	0.426096	tons/yr/sample
Erosion Rate	4.18176	tons/mile/year
Feet of Similar Stream Type	3400	ft
Eroding Bank Extrapoltation (with reduction)	1575.2	ft
Total Streambank Erosion	3.118896	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	1
Bank Condition (0-3)	0
Vegetative/cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	1
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	4
Recession Rate	**0.05**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Bunnel Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 3		*Upstream:* 47.117623,-116.726941	
Date Collected:		4/28/2005	*Downstream:* 47.116866,-116.725639	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:** intact forest	
Data Reduced By:	Mark Shumar		represents 950m of Bunnel, 1500m of upper Hangman,	

Streambank Erosion Calculations

Average Bank Height	0.99	ft
Total Inventoried Bank Length	643	ft
Inventoried Bank to Bank Length	1286	ft
Erosive Bank Length	46	ft
Bank to Bank Eroding Segment Length	92	ft
Percent Eroding Bank	0.07153966	%
Eroding Area	91.08	ft^2
Recession Rate	0.05	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.20493	tons/year/sample reach
Erosion Rate (Er)	1.68278445	tons/mile/year
Feet of similar stream type	16581	ft
Eroding Bank Extrapolation	2464.39813	ft
Total Streambank Erosion	5.48944684	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
1.682784448	5.4894468	4.70448	15.346584	-179.5652174

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	254.628	ft^2
Erosion over sampled reach (with load reduction (20%)	0.572913	tons/yr/sample
Erosion Rate	4.70448	tons/mile/year
Feet of Similar Stream Type	16581	ft
Eroding Bank Extrapoltation (with reduction)	6889.6	ft
Total Streambank Erosion	15.34658	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	1
Bank Condition (0-3)	0
Vegetative/cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	1
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	4
Recession Rate	**0.05**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Martin Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 1		*Upstream:* 47.07372,-116.7662	
Date Collected:		4/27/2005	*Downstream:* 47.07339,-116.7640	
Field Crew:	Zaroban et al.		**Landuse and Notes:**	forest-shrub mix
Data Reduced By:	Mark Shumar		represents 2000m of Martin and 2700m of Conrad	

Streambank Erosion Calculations

Average Bank Height	1.7	ft
Total Inventoried Bank Length	785	ft
Inventoried Bank to Bank Length	1570	ft
Erosive Bank Length	181	ft
Bank to Bank Eroding Segment Length	362	ft
Percent Eroding Bank	0.23057325	%
Eroding Area	615.4	ft^2
Recession Rate	0.12	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	3.32316	tons/year/sample reach
Erosion Rate (Er)	22.3519552	tons/mile/year
Feet of similar stream type	8073	ft
Eroding Bank Extrapolation	4084.83567	ft
Total Streambank Erosion	37.4987914	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
22.35195516	37.498791	19.38816	32.526576	13.25966851

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	533.8	ft^2
Erosion over sampled reach (with load reduction (20%)	2.88252	tons/yr/sample
Erosion Rate	19.38816	tons/mile/year
Feet of Similar Stream Type	8073	ft
Eroding Bank Extrapoltation (with reduction)	3543.2	ft
Total Streambank Erosion	32.52658	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	1
Bank Condition (0-3)	0
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	7
Recession Rate	**0.12**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Martin Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 2		*Upstream:* 47.07683,-116.7688	
Date Collected:		4/27/2005	*Downstream:* 47.07455,-116.7676	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:** grazed shrub	
Data Reduced By:	Mark Shumar		represents 600m of lower Martin	

Streambank Erosion Calculations

Average Bank Height	1.44	ft
Total Inventoried Bank Length	1375	ft
Inventoried Bank to Bank Length	2750	ft
Erosive Bank Length	507	ft
Bank to Bank Eroding Segment Length	1014	ft
Percent Eroding Bank	0.36872727	%
Eroding Area	1460.16	ft^2
Recession Rate	0.38	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	24.968736	tons/year/sample reach
Erosion Rate (Er)	95.8799462	tons/mile/year
Feet of similar stream type	594	ft
Eroding Bank Extrapolation	1452.048	ft
Total Streambank Erosion	35.75523	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
95.87994624	35.75523	52.005888	19.3938624	45.75936884

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	792	ft^2
Erosion over sampled reach (with load reduction (20%)	13.5432	tons/yr/sample
Erosion Rate	52.00589	tons/mile/year
Feet of Similar Stream Type	594	ft
Eroding Bank Extrapoltation (with reduction)	787.6	ft
Total Streambank Erosion	19.39386	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	1
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	11
Recession Rate	**0.38**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Tenas Creek	**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 6	*Upstream:* 47.06791,-116.76263	
Date Collected:	4/29/2005	*Downstream:* 47.06869,-116.76279	
Field Crew:	Zaroban et al.	**Landuse and Notes:** harvested forest	
Data Reduced By:	Mark Shumar	represents 950m of Tenas Creek	

Streambank Erosion Calculations

Average Bank Height	1.5	ft
Total Inventoried Bank Length	743	ft
Inventoried Bank to Bank Length	1486	ft
Erosive Bank Length	174	ft
Bank to Bank Eroding Segment Length	348	ft
Percent Eroding Bank	0.23418573	%
Eroding Area	522	ft^2
Recession Rate	0.09	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	2.1141	tons/year/sample reach
Erosion Rate (Er)	15.0234832	tons/mile/year
Feet of similar stream type	2374	ft
Eroding Bank Extrapolation	1459.91386	ft
Total Streambank Erosion	8.86897672	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
15.02348318	8.8689767	12.8304	7.57431	14.59770115

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	445.8	ft^2
Erosion over sampled reach (with load reduction (20%)	1.80549	tons/yr/sample
Erosion Rate	12.8304	tons/mile/year
Feet of Similar Stream Type	2374	ft
Eroding Bank Extrapoltation (with reduction)	1246.8	ft
Total Streambank Erosion	7.57431	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	2
Bank Condition (0-3)	1
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	1
Channel Bottom (0-2)	0
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	6
Recession Rate	**0.09**

Appendix E. Solar Pathfinder Data

Shade Calculator - Reach 1 Martin Creek

Site	1	2	3	4	5	6	7	8	9	10	Average	
Jan-Shade	84	68	16	100	93	100	100	100	95	100	85.6	67.2
Jan-Open	16	32	84	0	7	0	0	0	5	0	14.4	32.8
Feb-Shade	82	69	26	82	92	100	92	100	95	100	83.8	63.1
Feb-Open	18	31	74	18	8	0	8	0	5	0	16.2	36.9
Mar-Shade	73	89	59	69	93	100	93	100	89	100	86.5	59.9
Mar-Open	27	11	41	31	7	0	7	0	11	0	13.5	40.1
Apr-Shade	78	100	62	58	93	91	80	100	91	95	84.8	60.9
Apr-Open	22	0	38	42	7	9	20	0	9	5	15.2	39.1
May-Shade	78	100	77	54	71	75	61	100	77	72	76.5	58.2
May-Open	22	0	23	46	29	25	39	0	23	28	23.5	41.8
Jun-Shade	86	102	85	51	56	73	58	102	75	80	76.8	58
Jun-Open	16	0	17	51	46	29	44	0	27	22	25.2	44
Jul-Shade	78	100	77	49	62	75	61	100	73	78	75.3	57.6
Jul-Open	22	0	23	51	38	25	39	0	27	22	24.7	42.4
Aug-Shade	72	100	63	54	94	84	70	100	82	89	80.8	60.7
Aug-Open	28	0	37	46	6	16	30	0	18	11	19.2	39.3
Sep-Shade	72	93	60	62	93	100	93	100	94	100	86.7	58.6
Sep-Open	28	7	40	38	7	0	7	0	6	0	13.3	41.4
Oct-Shade	82	70	39	82	93	100	92	100	89	100	84.7	62.2
Oct-Open	18	30	61	18	7	0	8	0	11	0	15.3	37.8
Nov-Shade	84	68	24	100	93	100	100	100	95	100	86.4	68.3
Nov-Open	16	32	76	0	7	0	0	0	5	0	13.6	31.7
Dec-Shade	87	68	13	100	92	100	100	100	98	100	85.8	67.3
Dec-Open	13	32	87	0	8	0	0	0	2	0	14.2	32.7

Ave Shade	82.80833	R1+R2	72.32083
Ave Open	17.35833		
Summer Shade	80.15		
Summer Open	20.18333		

Shade Calculator - Reach 2 Martin Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	66	95	98	52	0	82	69	48	62	100	67.2
Jan-Open	34	5	2	48	100	18	31	52	38	0	32.8
Feb-Shade	65	83	92	37	0	62	67	56	69	100	63.1
Feb-Open	35	17	8	63	100	38	33	44	31	0	36.9
Mar-Shade	70	78	83	6	0	69	74	54	72	93	59.9
Mar-Open	30	22	17	94	100	31	26	46	28	7	40.1
Apr-Shade	69	100	92	2	0	59	73	72	57	85	60.9
Apr-Open	31	0	8	98	100	41	27	28	43	15	39.1
May-Shade	60	84	100	2	0	63	72	91	37	73	58.2
May-Open	40	16	0	98	100	37	28	9	63	27	41.8
Jun-Shade	52	75	102	2	0	63	73	102	36	75	58
Jun-Open	50	27	0	100	102	39	29	0	66	27	44
Jul-Shade	60	73	100	2	0	63	72	96	37	73	57.6
Jul-Open	40	27	0	98	100	37	28	4	63	27	42.4
Aug-Shade	58	100	100	2	0	59	73	76	59	80	60.7
Aug-Open	42	0	0	98	100	41	27	24	41	20	39.3
Sep-Shade	62	78	86	2	0	60	74	63	72	89	58.6
Sep-Open	38	22	14	98	100	40	26	37	28	11	41.4
Oct-Shade	58	82	91	36	0	63	66	55	71	100	62.2
Oct-Open	42	18	9	64	100	37	34	45	29	0	37.8
Nov-Shade	66	97	97	53	0	82	69	57	62	100	68.3
Nov-Open	34	3	3	47	100	18	31	43	38	0	31.7
Dec-Shade	69	97	99	51	0	86	70	43	58	100	67.3
Dec-Open	31	3	1	49	100	14	30	57	42	0	32.7

Ave Shade	61.83333
Ave Open	38.33333
Summer Shade	59
Summer Open	41.33333

Shade Calculator - Reach 3 Bunnel Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	100	100	100	100	100	100	100	100	100	100	100
Jan-Open	0	0	0	0	0	0	0	0	0	0	0
Feb-Shade	100	92	100	100	100	100	100	96	100	100	98.8
Feb-Open	0	8	0	0	0	0	0	4	0	0	1.2
Mar-Shade	86	88	100	98	100	86	100	79	86	100	92.3
Mar-Open	14	12	0	2	0	14	0	21	14	0	7.7
Apr-Shade	100	79	83	92	97	100	94	57	80	100	88.2
Apr-Open	0	21	17	8	3	0	6	43	20	0	11.8
May-Shade	100	88	80	91	83	94	97	60	78	100	87.1
May-Open	0	12	20	9	17	6	3	40	22	0	12.9
Jun-Shade	102	90	82	93	85	102	99	62	75	102	89.2
Jun-Open	0	12	20	9	17	0	3	40	27	0	12.8
Jul-Shade	100	88	80	91	83	94	97	60	78	100	87.1
Jul-Open	0	12	20	9	17	6	3	40	22	0	12.9
Aug-Shade	100	79	77	92	93	94	100	59	88	100	88.2
Aug-Open	0	21	23	8	7	6	0	41	12	0	11.8
Sep-Shade	93	90	100	95	100	86	93	73	86	100	91.6
Sep-Open	7	10	0	5	0	14	7	27	14	0	8.4
Oct-Shade	92	92	100	100	100	100	100	93	100	100	97.7
Oct-Open	8	8	0	0	0	0	0	7	0	0	2.3
Nov-Shade	100	100	100	100	100	100	100	100	100	100	100
Nov-Open	0	0	0	0	0	0	0	0	0	0	0
Dec-Shade	100	100	100	100	100	100	100	100	100	100	100
Dec-Open	0	0	0	0	0	0	0	0	0	0	0

Ave Shade	93.35
Ave Open	6.816667
Summer Shade	88.56667
Summer Open	11.76667

Shade Calculator - Reach 4 SF Hangman Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	100	100	100	100	100	100	100	100	100	91	99.1
Jan-Open	0	0	0	0	0	0	0	0	0	9	0.9
Feb-Shade	100	92	100	92	92	100	100	100	100	100	97.6
Feb-Open	0	8	0	8	8	0	0	0	0	0	2.4
Mar-Shade	81	93	100	81	100	93	93	100	94	89	92.4
Mar-Open	19	7	0	19	0	7	7	0	6	11	7.6
Apr-Shade	82	88	88	95	88	93	84	94	95	95	90.2
Apr-Open	18	12	12	5	12	7	16	6	5	5	9.8
May-Shade	71	82	88	84	70	90	100	88	100	100	87.3
May-Open	29	18	12	16	30	10	0	12	0	0	12.7
Jun-Shade	67	84	90	76	72	96	102	90	102	102	88.1
Jun-Open	35	18	12	26	30	6	0	12	0	0	13.9
Jul-Shade	65	82	88	79	70	94	95	88	100	100	86.1
Jul-Open	35	18	12	21	30	6	5	12	0	0	13.9
Aug-Shade	76	100	82	95	76	90	95	94	90	95	89.3
Aug-Open	24	0	18	5	24	10	5	6	10	5	10.7
Sep-Shade	81	93	100	87	100	93	89	93	94	89	91.9
Sep-Open	19	7	0	13	0	7	11	7	6	11	8.1
Oct-Shade	100	93	100	93	85	92	100	100	100	100	96.3
Oct-Open	0	7	0	7	15	8	0	0	0	0	3.7
Nov-Shade	100	100	100	92	100	100	100	100	100	100	99.2
Nov-Open	0	0	0	8	0	0	0	0	0	0	0.8
Dec-Shade	100	100	100	100	100	100	100	100	100	80	98
Dec-Open	0	0	0	0	0	0	0	0	0	20	2

Ave Shade	92.95833
Ave Open	7.208333
Summer Shade	88.81667
Summer Open	11.51667

Shade Calculator - Reach 5 Hangman Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	0	0	0	0	10	0	0	0	0	2	1.2
Jan-Open	100	100	100	100	90	100	100	100	100	98	98.8
Feb-Shade	0	0	0	0	9	0	0	0	0	1	1
Feb-Open	100	100	100	100	91	100	100	100	100	99	99
Mar-Shade	0	0	0	0	0	0	0	0	0	0	0
Mar-Open	100	100	100	100	100	100	100	100	100	100	100
Apr-Shade	0	0	0	0	0	0	0	0	0	0	0
Apr-Open	100	100	100	100	100	100	100	100	100	100	100
May-Shade	0	0	0	0	0	0	0	0	0	0	0
May-Open	100	100	100	100	100	100	100	100	100	100	100
Jun-Shade	0	0	0	0	0	0	0	0	0	0	0
Jun-Open	102	102	102	102	102	102	102	102	102	102	102
Jul-Shade	0	0	0	0	0	0	0	0	0	0	0
Jul-Open	100	100	100	100	100	100	100	100	100	100	100
Aug-Shade	0	0	0	0	0	0	0	0	0	0	0
Aug-Open	100	100	100	100	100	100	100	100	100	100	100
Sep-Shade	0	0	0	0	0	0	0	0	0	0	0
Sep-Open	100	100	100	100	100	100	100	100	100	100	100
Oct-Shade	0	0	0	0	5	0	0	0	0	2	0.7
Oct-Open	100	100	100	100	95	100	100	100	100	98	99.3
Nov-Shade	0	0	0	0	11	0	0	0	0	4	1.5
Nov-Open	100	100	100	100	89	100	100	100	100	96	98.5
Dec-Shade	0	0	0	0	7	0	0	0	0	4	1.1
Dec-Open	100	100	100	100	93	100	100	100	100	96	98.9

Ave Shade	0.458333
Ave Open	99.70833
Summer Shade	0
Summer Open	100.3333

Shade Calculator - Reach 6 Tenas Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	71	37	81	100	100	92	100	97	100	20	79.8
Jan-Open	29	63	19	0	0	8	0	3	0	80	20.2
Feb-Shade	67	28	68	93	100	78	79	97	100	28	73.8
Feb-Open	33	72	32	7	0	22	21	3	0	72	26.2
Mar-Shade	65	20	40	88	80	60	79	85	67	50	63.4
Mar-Open	35	80	60	12	20	40	21	15	33	50	36.6
Apr-Shade	51	8	35	70	55	45	57	78	59	33	49.1
Apr-Open	49	92	65	30	45	55	43	22	41	67	50.9
May-Shade	28	12	34	40	21	50	32	53	63	51	38.4
May-Open	72	88	66	60	79	50	68	47	37	49	61.6
Jun-Shade	35	17	9	38	14	51	23	43	61	47	33.8
Jun-Open	67	85	93	64	88	51	79	59	41	55	68.2
Jul-Shade	33	15	23	40	21	45	23	49	59	51	35.9
Jul-Open	67	85	77	60	79	55	77	51	41	49	64.1
Aug-Shade	39	10	43	65	49	53	46	78	56	47	48.6
Aug-Open	61	90	57	35	51	47	54	22	44	53	51.4
Sep-Shade	65	8	34	88	74	53	69	72	61	49	57.3
Sep-Open	35	92	66	12	26	47	31	28	39	51	42.7
Oct-Shade	68	24	61	93	96	71	75	98	97	30	71.3
Oct-Open	32	76	39	7	4	29	25	2	3	70	28.7
Nov-Shade	70	36	82	100	100	92	85	97	100	22	78.4
Nov-Open	30	64	18	0	0	8	15	3	0	78	21.6
Dec-Shade	72	34	70	100	100	91	100	100	100	10	77.7
Dec-Open	28	66	30	0	0	9	0	0	0	90	22.3

Ave Shade	58.95833
Ave Open	41.20833
Summer Shade	43.85
Summer Open	56.48333

Shade Calculator - Reach 7 Bunnel Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	66	100	75	100	87	92	100	81	100	100	90.1
Jan-Open	34	0	25	0	13	8	0	19	0	0	9.9
Feb-Shade	76	94	72	100	79	92	100	84	100	84	88.1
Feb-Open	24	6	28	0	21	8	0	16	0	16	11.9
Mar-Shade	100	93	89	90	74	74	100	74	100	86	88
Mar-Open	0	7	11	10	26	26	0	26	0	14	12
Apr-Shade	100	87	92	89	89	68	100	77	81	100	88.3
Apr-Open	0	13	8	11	11	32	0	23	19	0	11.7
May-Shade	100	100	92	92	95	83	100	88	77	88	91.5
May-Open	0	0	8	8	5	17	0	12	23	12	8.5
Jun-Shade	102	102	89	93	102	85	102	84	79	90	92.8
Jun-Open	0	0	13	9	0	17	0	18	23	12	9.2
Jul-Shade	100	100	92	92	95	83	100	88	77	88	91.5
Jul-Open	0	0	8	8	5	17	0	12	23	12	8.5
Aug-Shade	100	88	89	87	94	68	100	82	88	88	88.4
Aug-Open	0	12	11	13	6	32	0	18	12	12	11.6
Sep-Shade	100	86	93	86	76	74	100	81	100	86	88.2
Sep-Open	0	14	7	14	24	26	0	19	0	14	11.8
Oct-Shade	77	94	71	89	80	86	100	84	100	76	85.7
Oct-Open	23	6	29	11	20	14	0	16	0	24	14.3
Nov-Shade	66	100	70	100	87	92	100	82	100	100	89.7
Nov-Open	34	0	30	0	13	8	0	18	0	0	10.3
Dec-Shade	72	100	100	100	86	100	100	80	100	100	93.8
Dec-Open	28	0	0	0	14	0	0	20	0	0	6.2

Ave Shade	89.675
Ave Open	10.49167
Summer Shade	90.11667
Summer Open	10.21667

Shade Calculator - Reach 8 SF Hangman Creek

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	95	100	100	92	73	100	100	100	100	100	96
Jan-Open	5	0	0	8	27	0	0	0	0	0	4
Feb-Shade	95	100	92	63	60	100	89	100	92	94	88.5
Feb-Open	5	0	8	37	40	0	11	0	8	6	11.5
Mar-Shade	94	95	60	59	40	79	52	99	61	62	70.1
Mar-Open	6	5	40	41	60	21	48	1	39	38	29.9
Apr-Shade	90	86	68	35	56	86	35	100	27	47	63
Apr-Open	10	14	32	65	44	14	65	0	73	53	37
May-Shade	95	78	60	31	65	94	36	83	26	29	59.7
May-Open	5	22	40	69	35	6	64	17	74	71	40.3
Jun-Shade	97	79	62	28	73	90	38	68	27	30	59.2
Jun-Open	5	23	40	74	29	12	64	34	75	72	42.8
Jul-Shade	95	78	60	31	71	94	36	83	26	29	60.3
Jul-Open	5	22	40	69	29	6	64	17	74	71	39.7
Aug-Shade	95	86	70	37	64	88	34	94	29	39	63.6
Aug-Open	5	14	30	63	36	12	66	6	71	61	36.4
Sep-Shade	89	92	53	52	46	72	39	99	33	61	63.6
Sep-Open	11	8	47	48	54	28	61	1	67	39	36.4
Oct-Shade	95	100	79	56	54	100	100	100	80	87	85.1
Oct-Open	5	0	21	44	46	0	0	0	20	13	14.9
Nov-Shade	95	100	100	83	74	100	89	100	92	100	93.3
Nov-Open	5	0	0	17	26	0	11	0	8	0	6.7
Dec-Shade	100	100	100	100	71	100	100	100	100	100	97.1
Dec-Open	0	0	0	0	29	0	0	0	0	0	2.9

Ave Shade	74.95833
Ave Open	25.20833
Summer Shade	61.56667
Summer Open	38.76667

Appendix F. Bacteria Loading Analysis

Date	Hangman Creek E.coli (cfu/100ml)	5-day geomean	Estimated Flow (cfs)	# cfu at flow	# cfu at geomean ave. flow	SF Hangman Creek E.coli (cfu/100ml)	5-day geomean	Estimated Flow (cfs)	# cfu at flow	# cfu at geomean ave. flow
7/8/2002	1100		0.64	199351		730		0.57	117826	
7/22/2002	1300		0.33	121479		68		0.29	5584	
7/26/2002	730		0.31	64081		64		0.28	5074	
7/29/2002	2400		0.27	183493		26		0.24	1767	
8/2/2002	99	756.6605	0.2	5607	74992	1000	152.5447	0.18	50970	13477
8/5/2002	20	339.4912	0.22	1246	25571	1200	168.4879	0.2	67960	11355
8/9/2002	59	182.8985	0.23	3843	12741	21	133.202	0.21	1249	8374
8/13/2002	31	97.23397	0.24	2107	6388	370	189.1974	0.22	23050	11251

Appendix X. Distribution List

This is the list of those to whom you sent (will send) the TMDL.

Appendix X. Public Comments